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# USSR Report

MATERIALS SCIENCE AND METALLURGY

No. 63

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27 September 1979

USSR REPORT  
MATERIALS SCIENCE AND METALLURGY

No. 63

This serial publication contains articles, abstracts of articles and news items from USSR scientific and technical journals on the specific subjects reflected in the table of contents.

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METAL FATIGUE DETECTOR

Kishinev SOVETSKAYA MOLDAVIYA in Russian 2 Jun 79 p 2

/Article: "Diagnosis for 'Sick' Metal"/

/Text/ The metal "cried out" as if from pain, as soon as a hint of a crack appeared inside it. The unheard distress signal was picked up and recorded by means of a new ultrasonic instrument in one of the laboratories of the All-Union Scientific Research Institute of Developing Nondestructive Methods and Instruments for Quality Control, where it was developed. The Kishinev Volna Production Association has put the instrument into production.

In a special device in this laboratory they bent first in one direction, then in the other a steel band, to which a sensor of the AF-11 instrument was attached. At first the automatic recorder connected up to the instrument drew a straight line on the moving paper tape. But then it quivered, and a hardly perceptible indentation appeared on it, then a second one, a third one....

This was the first warning of impending danger. It came from where the crystal lattice began to break down in the steel band due to the heavy strain. A part of the energy arising here was transformed into ultrasonic waves. They were picked up by the sensitive sensor. The greater the defect that developed, the more sweeping the lateral lines were, which the automatic recorder drew on the paper tape. And when the steel band broke, it immediately froze.

The deformation noise received the name of acoustic emission. It has become a promising direction in ultrasonic defectoscopy, which makes it possible to develop instruments which detect the formation of cracks. This is especially important for their detection in operating boilers of power blocks, main pipelines and various crucial items. Such equipment makes it possible to test materials, parts and components in order to determine their strength characteristics.

7807  
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USSR

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## ELECTRODEPOSITION OF RHENIUM FROM FLUORINE-CONTAINING ELECTROLYTES

Moscow ZASHCHITA METALLOV in Russian Vol 15 No 4, 1979 pp 480-481 manuscript received 12 Apr 76

IVANOVA, N. D., TARANENKO, N. I. and GORODYSKIY, A. V., Institute of General and Inorganic Chemistry, Academy of Sciences UkrSSR

[Abstract] Rhenium coatings have many uses, since they do not form nitrides or carbides, are more oxygen-resistant than tungsten and molybdenum, and are more resistant to water vapor than tungsten. Normally, rhenium is deposited from aqueous solutions of perrhenates, with a yield of up to 25%. In this connection it is shown that, contrary to earlier assertions (U. S. Patent 2,138,573, September 1, 1934; German Patent 626,233, February 24, 1936), rhenium can be isolated from the aqueous solutions of perrhenates containing the fluorine ion as a catalytic additive. Electrolytes based on perrhenic acid and potassium and ammonium perrhenates were investigated. The concentration of rhenium was varied from 1 to 40 g/liter and that of the fluorine ion, from 5 to 150 g/liter; the electrolyte temperature, 20 to 100°C; and the current density, from 2 to 200 a/dm<sup>2</sup>. The optimal fluorine-containing electrolyte and mode of electrolysis assuring a maximum yield of 40-42% of rhenium metal were determined (for details, see N. D. Ivanova et al. EKSPRESS-INFORMATSIYA, SER.17, VYP. 5, ANTIKORROZIONNYYE I DEKORATIVNYYE POKRYTIYA, UkrNIINTI, 1973). The rhenium coatings thus obtained were 10-15 μm thick and were deposited on various materials: molybdenum, tungsten, stainless steel, in successive 4-5 μm layers annealed at 900-950°C. These coatings do not crack and contain practically no pores. The electrodeposition of rhenium coatings from fluorine-containing electrolytes is more rapid and economical than the traditional method, and can be recommended for widespread use. Figures 1; references 9: 7 Russian, 2 Western.

USSR

UDC 621.396.6.002:669.018.95

A STUDY OF THE DECOMPOSITION PROCESS OF BIS-ARENE COMPOUNDS OF CHROME AND THE PHYSICAL PROPERTIES OF THE COATINGS OBTAINED

Moscow NEORGANICHESKIYE MATERIALY in Russian Vol 15 No 5, 1979 pp 782-785 manuscript received 19 Dec 77

KOLESHKO, V. M., REZNIKOV, B. S. and UTKINA, YE. A., Institute of Electronics, Academy of Sciences BSSR

[Abstract] The substance tested was an organic chrome fluid containing bis-arene derivatives of chrome in which bis-ethylbenzole chrome predominated. The coating was deposited using a vertical reactor and infrared heating. Temperature changes in a range from 373° to 493°K at the vaporizer, and 573-773° K at the substrate, were the parameters for the rate of deposit of the film. Results showed the formation of a chrome coating above 423°K. At below 673°K at the substrate, irregular coatings formed; at above 873°K vaporization slowed the formation of the coating. The organic chrome films produced by this methodology were very hard and mechanically durable. An even coating appeared only at thicknesses above 600 Å. Figures 4; references 2 (Russian).

USSR

UDC 669.15:621.685.5

APPLYING A NIOBIUM CARBIDE COATING TO THE SURFACE OF INSTRUMENT STEELS

Moscow IVUZ. CHERNAYA METALLURGIYA in Russian No 4, 1979 pp 91-93 manuscript received 29 Sep 78

LOSKUTOV, V. F. and KHIZHNYAK, V. G., Kiev Polytechnical Institute

[Abstract] Steels used for the production of dies, taps, drills, and other instruments were coated in a partial vacuum at temperatures of 950-1100°C and periods of from 2 to 6 hours using technically pure niobium, polyethylene granules and carbon tetrachloride. The resulting samples were studied by x-ray structural, microstructural, durometrical and micro-x-ray spectral analysis. Analyses indicated that the carbide coatings contained, along with carbon and niobium, elements of the steel alloys such as iron and chrome. Both temperature and time affected the process, and the optimal thickness for coatings was considered to be 10-15 microns. The method used was found to increase durability and corrosion resistance and can be readily applied at any machine shop. References 5 (Russian).



USSR

UDC 539.216.1

## ANALYSIS OF THE INFLUENCE OF BRITTLE INTERLAYERS ON THE STRENGTH OF FIBER COMPOSITES

Moscow: FIZIKA I KHIMIYA OBRABOTKI MATERIALOV in Russian No 3, May/Jun 79  
pp 138-146 manuscript received 14 Feb 78

USTINOV, L. M., Moscow

[Abstract] The influence of brittle interlayers on tensile strength of fiber composites reinforced with brittle fibers is discussed from the standpoint of linear mechanics of fracture. An analysis of experimental material shows that fracture of a brittle fiber coated with a dissimilar brittle material (interlayer) in a matrix may follow two paths. In one case, a crack developing at a certain point in the interlayer moves toward the fiber, encounters the fiber material and subsequently spreads simultaneously through fiber and interlayer until fracture is complete. In the other case, the intensity of stresses induced by the crack as it reaches the fiber are relatively low, so that the crack propagates around the interlayer, which fractures before the fiber itself is broken. Analysis of the first type of fracture on a model of a semi-infinite two-component plate with edge crack yielded an expression for the coefficient of stress intensity at the vertex of the crack as the interlayer is deformed by fracture. This coefficient increases with increasing thickness of the interlayer. Analysis of the second type of fracture based on a model of a two-component rod of infinite length gave an expression for the coefficient of stress intensity at the vertex of an annular crack upon fracture deformation of the interlayer. As the thickness of the interlayer increases, this factor begins to decrease, passes through a minimum, and then slowly increases. Both graphs for the coefficient of stress intensity as a function of the thickness of the interlayer together form a diagram consisting of several regions, each corresponding to a certain type of dependence of breaking stress on interlayer thickness. All expressions that describe this relation show that there is a continuous reduction in breaking stress on the fiber with increasing thickness of the interlayer beyond a critical thickness. Figures 5; references 16: 6 Russian, 10 Western.

USSR

UDC 669.494

RELATION BETWEEN THE STRENGTH OF FIBER/MATRIX INTERFACES AND THE BREAKING STRENGTH OF ALUMINUM-BORON COMPOSITE MATERIAL

Moscow FIZIKA I KHIMIYA OBRABOTKI MATERIALOV in Russian No 3, May/Jun 79  
pp 132-137 manuscript received 9 Nov 78

SHORSHOROV, M. KH., USTINOV, L. M. and GUKASYAN, L. YE., Moscow

[Abstract] Studies were done on the relation between change in microstructure and strength properties of aluminum-boron composite subject to heat cycling. The material contained boron fibers about 0.1 mm in diameter in an aluminum matrix. The fiber content was about 38% by volume. Two heat cycles were used:  $1.20 \pm 400^\circ\text{C}$ , heating time 10 sec, cooling time 60 sec (forced cycle);  $2.20 \pm 400^\circ\text{C}$ , heating time 60 sec, cooling naturally in air (mild cycle). Tensile and shear tests were done on an Instron machine at a strain rate of 1 mm/min, and microstructural and fractographic studies were done on the JSM-3M scanning electron microscope. It was found that rolled composites of the investigated type have a nonhomogeneous matrix. Heat cycling in the forced mode weakens the bond between fiber and matrix after only a single cycle with formation of cracks and a change in fracture from noncumulative to cumulative. A single mild cycle has no appreciable effect on composite structure. After 30 forced cycles, the specimens showed mixed fracture: sections of cumulative fracture were interspersed with sections of noncumulative fracture. The authors thank V. F. MANUYLOV and V. V. BELOV for furnishing the composite material, and for comments relating to the heat cycling technique. Figures 4; references 9: 7 Russian, 2 Western.

USSR

UDC 539.375:678.5.06

THE THEORY OF VISCOELASTICITY OF COMPOSITE MATERIALS

Riga MEKHANIKA KOMPOSITSIONNYKH MATERIALOV in Russian No 3, 1979 pp 414-423  
manuscript received 11 Aug 78

POBEDRYA, B. YE., Moscow State University imeni M. V. Lomonosov

[Abstract] A method is suggested for the design of viscoelastic composite materials with regular structure. The material analyzed is assumed to have a periodic structure. The method is based on asymptotic expansion of the solution of the equations derived in the article with respect to a small parameter; therefore, the solution is more accurate, the smaller the size of a unit cell of the material. References 8 (Russian).

USSR

UDC 539.3:678.5.06

OPTIMIZATION OF THE REINFORCEMENT SYSTEM OF A COMPOSITE FOR DEFORMABILITY  
AT PREDETERMINED STRESSES

Riga MEKHANIKA KOMPOSITSIONNYKH MATERIALOV in Russian No 3, 1979 pp 407-413  
manuscript received 13 Oct 78

KREGER, A. F., and MELNARDIS, YU. G., Institute of Polymer Mechanics, Academy of Sciences, Latvian S.S.R.

[Abstract] A study is made of problems involved in the determination of reinforcement layout to achieve minimum deformation when several different stress states are applied to the composite material. The criterion of optimality of the reinforcement layout is based on the concept of the surface of deformation of the material. This is a surface which allows a graphically clear image of the deformation properties of the material to be produced, and is constructed from a mathematical model of the material by a method described in this article. To achieve the maximum rigidity, practically all of the reinforcement must be aligned with the expected direction of maximum stress or, if the ratio of the moduli of elasticity of the material and reinforcement is not as great, the reinforcement should be angled slightly and symmetrically relative to the main stress axis.

USSR

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SPECIFICS OF THE FRACTURE OF ORGANOPLASTICS AND THEIR INFLUENCE ON STRENGTH

Riga MEKHANIKA KOMPOSITSIONNYKH MATERIALOV in Russian No 2, Mar/Apr 79 pp 317-321 manuscript received 20 Sep 78

PEROV, B. V., SKUDRA, A. M., MASHINSKAYA, G. P., BULAVS, F. YA., All-Union Scientific Research Institute of Aviation Materials, Moscow; Riga Polytechnical Institute

[Report presented at Soviet-American Symposium on Fracture of Composite Materials, Riga, September 1978]

[Abstract] A study is presented of the mechanism of fracture of plastics reinforced with organic fibers, a new, effective type of composite material, and of the influence of this fracture mechanism on the tensile, compressive and shear strength of organoplastics. The high strength and rigidity of the fibers used results from the high degree of orientation of macromolecules along the fiber axis and of the high energy of dissociation of the chemical bonds in the polymer chain. As the material is subjected to tensile stress, redistribution occurs not only through the polymer matrix from fiber to fiber, but also by the interaction of bundles of fibrils

within a single fiber, which are loaded to varying degrees. Photomicrographs are presented of specimens which have been deformed or have failed under tensile, shear and compressive stress. It is noted that defects in the polymer fibers, by increasing the surface area of contact with the binder, actually improve the mechanical bonding of the fiber with the matrix and thus increase the strength of the composite material. Figures 9; references 2 (Russian).

USSR

UDC 621.762:669.71:536.2

#### THERMOPHYSICAL PROPERTIES OF ALUMINUM-BASED COMPOSITE MATERIALS

Kiev POROSHKOVAYA METALLURGIYA in Russian No 5, 1979 pp 61-64 manuscript received 2 Oct 78

KARPINOS, D. M., KADYROV, V. KH., MOROZ, V. P. and MIROSHNIKOVA, T. K.,  
Institute of Problems of Material Science, Academy of Sciences UkrSSR

[Abstract] The thermal conductivity and coefficient of thermal expansion (CTE) of aluminum-based composites reinforced with fibers of boron (20-33 vol.%) silicon carbide (33 and 46 vol.%), and N16K4M5T2 steel (24 vol.%) were investigated. CTE was determined with the aid of a Chevenard quartz dilatometer on specimens heated in an electric vacuum furnace at 20-100, 20-200, 20-300, 20-400, and 20-500°C. Plots of the temperature dependence of thermal expansions of these composite materials show that their elongation per unit length increases with an increase in temperature and decreases with an increase in the proportion of fibers present. N16K4M5T2 steel-reinforced and SiC-reinforced aluminum composites display lower thermal expansion than their B-reinforced counterparts, given the same vol.%. Similarly, the thermal conductivity of B-reinforced aluminum differs by 25% from the thermal conductivity of SiC-reinforced aluminum. These findings can be used to predict the properties of composite materials and to improve their production technology. Figures 5; references 8: 7 Russian, 1 Western.

USSR

UDC 539.4:678.5.06

# VARIATION IN THE STRENGTH OF COMPOSITE MATERIALS AS A FUNCTION OF STRUCTURAL PARAMETERS

Riga MEKHANIKA KOMPOSITSIONNYKH MATERIALOV in Russian No 2, Mar/Apr 79 pp 291-296 manuscript received 25 Oct 78

LOMAKIN, V. A., Moscow State University imeni M. V. Lomonosov

[Report presented at Soviet-American Symposium on Fracture of Composite Materials, Riga, September 1978]

[Abstract] Many different approaches have been taken to the study of the problem of the strength of composite materials in recent years. Two are considered most promising: analysis of these materials as quasi-homogeneous media, using the traditional means and method of experimental and theoretical analysis used in the mechanics of solids; and analysis of the composite material as a structure consisting of individual elements which interact with each other. This article studies a unidirectional fiber-reinforced composite material in tension, although the conclusions are applicable to other composite materials and other types of stress. An equation is derived which determines the optimal ratio of elastic and strength properties for a composite material, so that failure will occur simultaneously through the fibers and the matrix. References 16: 12 Russian, 4 Western.

USSR

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# VOLUME FAILURE OF UNIDIRECTIONAL COMPOSITES

Riga MEKHANIKA KOMPOSITSIONNYKH MATERIALOV in Russian No 2, Mar/Apr 79 pp 260-267 manuscript received 20 Sep 78

TAMUZH, V. P., Institute of Polymer Mechanics, Academy of Sciences Latvian SSR, Riga

[Report presented at Soviet-American Symposium on Fracture of Composite Materials, Riga, September 1978]

[Abstract] A brief review is presented of studies of failure within the body of heterogeneous materials. The kinetics of development and enlargement of defects in fiber composites is studied using a model in which a defect of any size is considered to be a spheroid or circular, flat crack,

and the probability of failure of an element with a specific level of prestress is assigned by a certain equation similar to the equation for radioactive decay of a material, and is assumed to be independent of the loading history of the element. The statistical characteristics of strength and durability of structural composite elements are analyzed, and a numerical example is presented of the calculation of the accumulation of defects in glass-reinforced plastics as a function of the distribution of the durability and structural elements for various stress levels. Figures 4; references 16: 12 Russian, 4 Western.

USSR

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#### OPTIMAL STRUCTURE AND STRENGTH OF MULTILAYER COMPOSITES IN A PLANAR STRESS STATE

Riga MEKHANIKA KOMPOSITSIONNYKH MATERIALOV in Russian No 2, Mar/Apr 79 pp 228-234 manuscript received 20 Sep 78

OBRAZTSOV, I. F., VASIL'YEV, V. V., Moscow Aviation Institute imeni S. Ordzhonikidze; Moscow Institute of Aviation Technology imeni K. S. Tsiolkovski

[Report presented at Soviet-American Symposium on Fracture of Composite Materials, Riga, September 1978]

[Abstract] A study is made of thin multilayer composites which have the maximum strength in a plane stress state. A mathematical method is presented for determination of the optimal angle of reinforcement of each individual layer. Then the equations obtained are used to derive an expression for thickness to determine the global optimum of strength of a multilayer composite material experiencing plane stress. Figures 2; references 6: 5 Russian, 1 Western.



## MODELS OF THE FAILURE OF COMPOSITES WITH VARIOUS REINFORCEMENT STRUCTURES

Riga MEKHANIKA KOMPOSITSIONNYKH MATERIALOV in Russian No 2, Mar/Apr 79 pp 222-227 manuscript received 20 Sep 78

RIKARDS, R. B., TETERS, G. A., UPITIS, Z. T., Institute of Polymer Mechanics, Academy of Sciences Latvian SSR, Riga

[Report presented at Soviet-American Symposium on Fracture of Composite Materials, Riga, September 1978]

[Abstract] Materials with various structures were studied in a two-dimensional stress state in order to determine the regularities which govern the failure of multilayer composites as the structure of the reinforcement changes. Glass-reinforced plastics were used, made with the ETST-1 and EFB-3 binder materials containing a 50-mm-wide strip of glass fiber. The maximum values of tensile, compressive, shear and combined stresses were determined. Thirteen structures with various quantities of reinforcement were studied, and for each one an equation was used to determine the components of the strength surface tensors. A theoretical model of failure was also analyzed, based on micromechanical analysis of the beginning of fracture in the components making up the composites. Finally, mechanoluminescence in glass-reinforced plastics was studied using standard tensile-testing specimens, and a relationship was observed between luminescence and processes of destruction in the composite material. The first processes of destruction were found to begin at about 58% of the failure strain, and the luminescence data agreed rather well with the theoretical calculations of the beginning of crack formation, performed by the method of finite elements. Figures 10; references 7 (Russian).

## DIGITAL COMPUTER MODELING OF THE PROCESSES OF FRACTURE OF COMPOSITES WITH DEFECTS IN THE BONDING BETWEEN THE COMPONENTS

Riga MEKHANIKA KOMPOSITSIONNYKH MATERIALOV in Russian No 2, Mar/Apr 79 pp 217-221 manuscript received 20 Sep 78

KOP'YEV, I. M., OVCHINSKIY, A. S., and BILSAGAYEV, N. K., Institute of Metallurgy imeni A. A. Baykov, Academy of Sciences USSR, Moscow

[Report presented at Soviet-American Symposium on Fracture of Composite Materials, Riga, September 1978]

[Abstract] The fracture of individual fibers in a composite may cause the fracturing of neighboring fibers or may cause partial separation of the fractured fiber from the matrix. Modeling of these processes can trace the accumulation of damages, the development of cracks both in the direction of the reinforcement and in the transverse direction, and determine the point of transition from the stage of accumulation of damage to the stage of total failure of the material. The information obtained in modeling allows prediction of the strength characteristics of composites on the basis of data on the properties of the components, the nature of their bonding in the composite and the structure of the composite. The process of failure was modeled on a computer in order to predict the strength properties of composites with brittle fibers by determining the critical stress at which failure of individual fibers and the accompanying separation between fibers and matrix begins to occur. Modeling was conducted both for fibers with ideal bonding with the matrix and for composites in which the true statistical nature of the strength of the bond between components was considered. A Minsk-22 computer was used in the study. It is hoped that future studies can be conducted on a computer with greater memory capacity, to allow prediction of the optimal value of bond strength. Figures 4; references 4 (Russian).



## STUDY OF THE KINETICS OF FAILURE OF COMPOSITE MATERIALS

Riga MEKHANIKA KOMPOSITSIONNYKH MATERIALOV in Russian No 2, Mar/Apr 79  
pp 211-216 manuscript received 20 Sep 78

REGEL', V. R., LEKSOVSKIY, A. M., POZDNYAKOV, O. F., Physico-Technical  
Institute imeni A. F. Ioffe, Academy of Sciences USSR, Leningrad

[Abstract] A discussion is presented of two aspects of the problem of the study of composite materials as artificially created heterogeneous solids. First, the question is studied as to what sequences of events makes up the process of fracture of composites; then the influence of the surface of the second component on the properties of the first component of the composite material is studied. In both cases, model polymer composites are used for the experimental studies. The model composites consist of bundles of parallel fibers of capron and polypropylene contained in resin and polyoxyethylene matrices. The specimens contain fiber and resin in a volumetric ratio of 7;3, and the strength of the fibers was approximately 50 times that of the resin. The presence of the resin matrix was found to triple the durability of the fibers. The studies showed the prime importance of investigating the influence of the division boundary between the components of the composite on its mechanical properties. Figures 6; references 8: 6 Russian, 2 Western.

## AUTOMATIC SYSTEM OF CATHODE CORROSION PROTECTION

Moscow VODNYI TRANSPORT in Russian 9 May 1979, p 2

[Article by T. Andreyeva, coworker of the All-Union Scientific Research Institute of Interbranch Information: "Medicine for Metal--The Luga-1"]

[Text] The metal disease called corrosion has been termed by experts the problem of the century. This is no accident. Each year it destroys millions of tons of metal. Figuratively speaking, every tenth blast furnace works to feed it. For example, in the United States alone, according to the National Bureau of Standards, "the cost of the entire problem" is estimated at \$70 billion annually. This prompts scientists in many of the world's countries to consider ways of suppressing the "epidemic" of corrosion.

Corrosion causes a lot of trouble to seamen. At present, ships' operating conditions are sharply changing: traveling speeds are increasing as does cruising time, and the use of stronger alloys results in reducing the weight of the hull and the thickness of its plating. But corrosion continues and sometimes is even more wily. Its prevention by the traditional method of applying primer coatings is unworkable. As for ship repair, that is a bothersome and expensive affair. Worn plating sheets have to be replaced, the welded joints have to be renewed, and so on. Dry-dock operations cost thousands and tens of thousands of rubles. And most importantly, this immobilizes shipping that could otherwise have been used to transport a great deal of cargo or catch thousand of tons of fish.

How to solve this problem? This is not so simple. The more complex the alloys are, the more difficult they are to "cure." Saltwater causes pitting of the metal so that it cracks and disintegrates. To save it, the "disease" must be prevented.

For years experts at the Leningrad Scientific-Production Association "Ritm" in collaboration with the Central Scientific Research Institute of the Merchant Marine have been searching for an effective method for protecting the underwater part of ship hulls from marine corrosion. They started from scratch. There was no prior experience in such research. Difficulties were encountered at every step. But they were enthusiasts and had faith in

their ultimate success. Electricity came to their aid. Thus the cathodic protection system was conceived.

The Chief of the Ritm Laboratory, Candidate of Engineering Sciences Yu. Kuz'min, commented: "As you know, the hull of a ship is made of steel, which is inhomogeneous by nature, with a surface of varying potential, which results in the appearance of corrosion currents. These currents destroy some sections of the hull while others--cathodic, as the experts term them--remain undamaged. Scientists proposed to make the entire hull a single cathode, as it were, that is insusceptible to corrosion, on the basis of cathodic polarization. To this end, special protectors of aluminum or of magnesium alloys are installed in hull plating. Then the water in which the ship floats acts as an electrolyte, that is, electric current flows, as in a battery, from the more active to the less active metal. And under the action of seawater it is the protector that gets dissolved, not the hull itself. The protector sacrifices itself, as it were, and protects the metal plating."

Seemingly the problem has been solved, but not entirely. Although the protection thus afforded is simple and inexpensive, and effective on ships with small displacement, it cannot prevent the corrosion of large tankers and bulk carriers. How much protector metal is needed considering that on medium-sized ships their weight averages two to three tons? But the most deplorable thing about it is that, by sacrificing itself, the metal of the protectors is irreversibly lost to the sea. That is why, once every two to four years new protectors have to be installed.

The Luga-1 cathodic protection system proposed by scientists is free of these shortcomings. Once installed on a ship under construction, it continues to serve the ship throughout its service life. Unlike the protector system, the Luga-1 is self-adjusting during its operation, untouched by human hand. The cathodic protection reliably safeguards the underwater parts of the hulls of large carriers and fishing vessels regardless of the plating material, the state of the primer coating, and operating conditions.

The development of the typical Luga-1 automatic cathodic protection system was preceded by prolonged tests performed by organizations of the shipbuilding industry, the merchant fleet, the fishing fleet and other departments. Such systems have been installed in passenger and bulk cargo ships, e.g., those of the Tadzhikistan, Petrozavodsk, and Komissar Polukhin types. They finally proved their worth. How are they being introduced in water transport? We asked this question of the Chief of the Corrosion Sector at the Central Scientific Research Institute of the Merchant Marine, Candidate of Engineering Sciences Yu. Zobychev.

He answered: "Currently the Luga-1 is being installed on many transport and fishing ships under construction in this country--the Heroic Panfilovets type, the Zoya Kosmodem'yanskaya type and others. We have received positive responses from various steamship companies. For example, a letter from Kamchatka states that the Luga-1 satisfactorily protects ships against

corrosion, prolongs the service life of the primer coating, and reduces repair work by nearly half.

"The annual savings due to the use of such a cathodic system when installed on a ship with a displacement of 10,000 tons amount to 15,000-20,000 rubles, and on a Krym-type tanker, around 100,000 rubles.

1386

CSO: 1842

## EFFECT OF AGING TEMPERATURE ON THE CORROSION CRACKING PRONENESS OF MARTENSITICALLY AGING EP699, EP678, AND EP679 HIGH-STRENGTH STEELS

Moscow ZASHCHITA METALLOV in Russian Vol 15 No 4, 1979 pp 416-420 manuscript received 4 Jul 77

ROZENFEL'D, I. L., SPIRIDONOV, V. B., KONRADI, M. V., KRASNORUTSKAYA, I. B. and FRIDMAN, V. S., Institute of Physical Chemistry, Academy of Sciences USSR

[Abstract] The role of aging temperature in the whole of the factors determining the corrosion cracking (CC) proneness of EP699, EP678, and EP679 high-strength martensitically aging carbon-free steels containing chromium as the principal alloying element was investigated. These steels differ in the content and type of the alloying elements (Cu, Mo, Ti) causing hardening during aging. CC proneness was determined in smooth stressed specimens in 3% NaCl upon using electrochemical polarization (initially anodic, which facilitates the corrosion pitting of the metal surface, and thereupon cathodic until fracture). Tensile stress  $\sigma = 0.9\sigma_{0.2}$  was induced by bending, and the density of anodic and cathodic currents was  $10 \text{ ma/cm}^2$ ; this method serves to determine the CC proneness of materials within 24 hr. In the quenched state the investigated steels are not CC-prone. The maximum sensitivity to CC was displayed by these steels at aging temperatures assuring maximum strength (470-500°C): precisely within that temperature range the maximum hardening of steels (the aging peak) is reached; then ductility and resistance to brittle fracture markedly diminish. Upon overaging, the CC resistance of the steels increases and they become virtually insusceptible to CC at aging temperatures exceeding by 20-30°C the "aging peak" for the individual steels. The increase in the CC resistance of the steels is associated with the loss of coherence between the hardening phase and the matrix when in the overaged state, i.e., with the marked decrease in the level of coherent stresses at overaging, as well as with the attendant increase in inter-particle distance owing to coagulation, and with the appearance of secondary austenite, which improves the possibilities for stress relaxation at the apex of the growing crack. Figures 2; references 5: 2 Russian, 3 Western. [171-1386]

## ANODIC BEHAVIOR OF TITANIUM AND Ti+2% Ni ALLOY IN NEUTRAL AND ALKALINE CHLORIDE SOLUTIONS

Moscow ZASHCHITA METALLOV in Russian Vol 15 No 4, 1979 pp 454-456 manuscript received 6 Jun 78

RISKIN, I. V. and TIMONIN, V. A., All-Union Scientific Research Institute for the Protection of Metals Against Corrosion

[Abstract] Titanium as the basis for various kinds of anodes and as a structural material in piping and equipment in chlorine production may be subject to intense local corrosion owing to anodic leakage currents. The resistance of Ti against such corrosion can be enhanced by treating it with alloy elements assuring a more negative potential of such anodic currents. In this connection, the behavior of Ti and the alloy Ti + 2% Ni at anodic polarization from a stationary potential until pitting formation in solutions of 1 and 300 g/liter and 120 g/liter NaOH + 200 g/liter NaCl at 90°C (which correspond to the technological media used in chlorine production) was investigated. The specimens used measured 6-8 cm<sup>2</sup> in area and were shaped like blades and cylinders with an insulated current-conducting core. The polarization was conducted in the potentiodynamic (2.88 v/hr) and galvanostatic modes at a current density of 0.2-10 ma/cm<sup>2</sup> for 5-20 hr. Alloying with nickel had virtually no effect on the pitting-formation potential but it increased the anodic current density by roughly an order of magnitude. The anodic current in the presence of a 1.5-2.0 v potential increases with increase in chloride concentration for the titanium anode, whereas it decreases for the Ti+2% Ni anode; this points to the segregation of oxygen rather than of chlorine on the Ti+2% Ni anode. In the alkali solution the anodic behavior of Ti and Ti+2% Ni differs still more markedly: at 1.6 v the anodic curve for Ti reaches its maximum, whereas for Ti+2% Ni the rate of current increase with potential then merely decreases slightly. The pitting of titanium begins at 6.5-6.6 v and at a current density of about 2 ma/cm<sup>2</sup>, whereas the current density for the Ti+2% Ni alloy reaches 60-70 ma/cm<sup>2</sup> already at 1.3 v. Thus, the treatment of Ti with Ni does not affect its resistance in chloride media and sharply reduces the oxygen overvoltage. This protects titanium against local corrosion in neutral and, particularly, alkaline chloride solutions. Inclusions of the intermetallic compound Ti<sub>2</sub>Ni clearly serve as effective anodes. It can be expected that increasing the concentration of the intermetallic compound at the metal surface can still further increase the anodic current density in the neighborhood of the 2 v potential. Figures 1; references 11: 9 Russian, 2 Western.

[171-1386]



USSR

UDC 620.193.01

**ELECTROCHEMICAL AND CORROSION PROPERTIES OF METAL-CERAMIC ALLOYS OF TITANIUM WITH MOLYBDENUM**

Moscow ZASHCHITA METALLOV in Russian Vol 15 No 3, 1979 pp 327-330 manuscript received 12 Jun 78

TOMASHOV, N. D., CHERNOVA, G. P., and MANSKIY, YE. G., Institute of Physical Chemistry, Academy of Sciences USSR

[Abstract] Porous metal-ceramic titanium alloys containing from 15 to 33% molybdenum were studied in various concentrations of sulfuric acid at temperatures ranging from 25° (for 9 hours) to 100° (for 8 hours). The alloys were found to have high corrosion resistance in sulfuric acid, and also in hydrochloric acid, with variations recorded depending on concentration and temperatures, indicating the most durable to be the 33% molybdenum alloy. Powder metallurgy procedures show promise for producing articles for use in aggressive environments. Figures 2; references 8: 7 Russian, 1 English.

USSR

UDC 620.197.7

**AN INVESTIGATION OF THE EFFECT OF CORROSION INHIBITORS ON THE KINETICS OF ELECTRON REACTIONS ON MAGNESIUM**

Moscow ZASHCHITA METALLOV in Russian Vol 15 No 3, 1979 pp 352-354 manuscript received 4 Jan 78

SHABAROVA, M. V., All-Union Scientific Research Institute of Petrochemical Processes

[Abstract] Inhibitors labeled M-22 and VNK-7 were tested on deformed and unoxidized MA-8 magnesium alloy specimens after polishing and cleaning with ethyl spirits. After application of the inhibitors, samples were placed in a cell with a silver chloride electrode and a 3% solution of NaCl as electrolyte. The alloy had a passivating effect. Results showed that the M-22 inhibitor retarded both anode and cathode reactions, while VNK retarded only the cathode reaction. Figures 2.

## EFFECT OF DIAMOND HONING ON THE CORROSION RESISTANCE OF MAGNESIUM ALLOYS

Moscow ZASHCHITA METALLOV in Russian Vol 15 No 4, 1979 pp 461-462 manuscript received 29 Aug 78

MOSTKOVA, I. B., All-Union Correspondence Institute of Textile and Light Industry

[Abstract] While the air in most textile-enterprise shops using diamond-honed magnesium-alloy components is pure and fairly dry ( $< 75\%$ ), prolonged operation may entail temporary increases in relative air humidity (up to 75-90%) and in the concentration of corrosive gases. In this connection, the atmospheric corrosion of specimens of magnesium alloys (cast ML5 alloy and shaped MA2-1 alloy) following the lathe-turning of the surfaces of some specimens and diamond-honing of the surfaces of others was investigated. The corrosion tests were conducted at room temperature in a humidity chamber (85% humidity) above a 6N sulfuric acid solution. The tests lasted 90 days and the acid solution was renewed once every 30 days. The corrosion of magnesium involves a lengthy incubation period which for the MA2-1 alloy is twice as long as for the ML5 alloy. Diamond-honed specimens were found to be more resistant to corrosion than lathe-turned specimens. At operation of textile machinery in heated premises, conditions conducive to corrosion arise only on certain days in the spring and summer season when the buildings are not heated. Calculations show that in the temperature zone of the USSR the number of such days does not exceed 5-10 annually. Thus it can be concluded that under the given conditions corrosion will not adversely affect the quality of honed parts of machinery for several years. Figures 1; references 3 (Russian).  
[171-1386]



## INVESTIGATION OF THE CORROSION PRODUCTS OF MAGNESIUM-LITHIUM ALLOYS PRONE AND NOT PRONE TO EXFOLIATING CORROSION

Moscow ZASHCHITA METALLOV in Russian Vol 15 No 4, 1979 pp 463-465 manuscript received 10 Jan 78

MOROZOVA, G. I., TARASENKO, L. V. and MUKHINA, I. YU., All-Union Scientific Research Institute of Aviation Materials

[Abstract] Cast magnesium-lithium alloys containing more than 15% lithium are prone to exfoliating corrosion when exposed to a tropical climate. In view of the relative lack of knowledge about the mechanism of that corrosion, Mg alloys containing 12 and 15% Li and treated with the same proportions of Al, Zn, Mn, and rare-earth metals were checked for corrosion by being kept for from 1 month to 1.5 years in a tropical-air chamber at a temperature of 40°C and humidity of 90%. At various intervals corrosion products were mechanically removed from the specimen surfaces and subjected to x-ray structural analysis. Both these alloys belong in the  $\alpha + \beta$  region with the predominance of the  $\beta$ -phase of the Mg-Li diagram of state (solid solution of Li in Mg with body-centered Li lattice) in the alloy with 15% Li. The alloy with 12% Li was found to be non-prone to exfoliating corrosion after 1.5 years of exposure. Friable white-yellow layers consisting of  $Mg(OH)_2$  and  $5MgO \cdot 4CO_2 \cdot 5H_2O$  formed on its surface. On the alloy with 15% Li analogous corrosion products were observed only upon exposure for up to 3 months. Following longer periods, the surface of that alloy began to display signs of exfoliating corrosion--bulges coated with a dense crust. After 1.5 years the exfoliating corrosion became distinct. The upper white layer of corrosion products consisted of magnesium hydroxide and the underlying denser yellowish layer additionally contained  $LiOH$ ,  $MgCO_3$ , and  $Mn_3O_4$ . ( $LiOH$  absorbs  $CO_2$  from the air, while the  $Mn_3O_4$  accounts for the yellowish color.) The subsurface layer is gray and dark-grey and consists of  $\alpha$ - and  $\beta$ -phases, spinel  $(Mg, Zn)Al_2O_4$ , and  $Mg(OH)_2$ . The amount of the  $\beta$ -phase and the Li concentration in these layers are smaller than in the inner layers: apparently, the lithium used in the formation of the corrosion products is drawn chiefly from the  $\beta$ -phase. In 3% NaCl under the conditions of hydrogen depolarization no exfoliation of alloys with 15% Li was observed. Thus, the difference in the corrosion properties of the alloys with 12 and 15% Li (treated with the same amounts of other alloy elements) may be due to the differing amount of the  $\beta$ -phase in these alloys as well as to their differing content of  $LiOH$  in their surface corrosion products. To prevent the exfoliating corrosion of the alloy with 15% Li, the share of the more corrosion-resistant  $\alpha$ -phase should be enlarged either by adding  $\alpha$ -stabilizers or applying low-temperature heat treatment with allowance for the polymorphic transformations of lithium. References 3 (Russian). [171-1386]

USSR

UDC 536.212+536.631

## CHANGES IN THE STRUCTURE AND THERMOPHYSICAL PROPERTIES OF GRAPHITE UNDER PRESSURE

Minsk IZVESTIYA AKADEMII NAUK BELORUSSKOY SSR, SERIYA FIZIKO-TEKHNICHESKIKH NAUK in Russian No 2, Apr/Jun 79 pp 5-8 manuscript received 7 Feb 78

SEVERDENKO, V. P. (deceased), KANTIN, V. G. and ANISHCHIK, V. M., Physico-Technical Institute, Academy of Sciences Belorussian SSR

[Abstract] Graphite and graphite-base powder are used in metal fabrication processes as lubricating and force-transmitting buffer materials. A study was made to determine the effect of textural and structural changes in lamellar phanero-crystalline graphite grades GSM-1, GAK-2, EUZM, S-1 and S-1(0) from the Zaval'ye deposits on their thermophysical properties at various molding temperatures and pressures. The lattice parameters were measured with a DRON-2.0 diffractometer using Bragg-Brentano focusing, the specimens having been molded under hydrostatic pressures of 11.84 or 22.2 kgf/mm<sup>2</sup>. The packing defectiveness in terms of the interplanar distance revealed an average lattice disorder factor of 0.18, and the differences in orientation volumes indicated differences in the thermophysical properties as well. Direct measurements over the temperature range from 400 to 1200°K have confirmed that the specific heat of these graphites in the direction transverse to the direction of molding does not depend on the technological parameters and varies with the temperature according to the relation  $C_p = 4.10 + 1.02 \cdot 10^{-3} T - 2.10 \cdot 10^{-5} T^2$  cal/(C·mole), while their thermal conductivity in the same direction depends on the crystal structure as well as on the degree of graphitization and other technological parameters. The density of graphite becomes maximum under a pressure of 18-20 kgf/mm<sup>2</sup>, whereupon its crystal structure changes with a further rise in pressure. Figures 2; references 4: 3 Russian, 1 Western.

USSR

UDC 669.295:539.292

## EFFECT OF HEAT TREATMENT AND DEVIATIONS FROM STOICHIOMETRY ON THE STRUCTURE AND PHYSICAL PROPERTIES OF TITANIUM NICKELIDE

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 7, 1979 pp 59-61

BELOUSOV, O. K., Institute of Metallurgy imeni A. A. Baykov

[Abstract] A study was made of the effect of prolonged annealing and quenching from high temperatures on the structure and physical properties of TiNi alloys containing 48-53 at.% Ni. The alloy compositions were selected within a narrow range of concentrations at intervals of 0.1-0.2 at.%. The melting was by the arc method in a helium atmosphere, followed by casting of alloy rods measuring 4 mm in diameter and 55 mm in length, which were quenched in water from 980°C and annealed at from 450 to 800°C for periods of from 48 to 216 hr, with some specimens being kept instead at room temperature for 5,500 hr. Thereupon, the specimens were tested for density (by the hydrostatic method), resistivity, thermo-e.m.f. (by the compensation method), and magnetic susceptibility (by suspending the specimen in magnetic field). The density curves of quenched and annealed alloys displayed an inflection point for the alloys containing 50.8% Ni. In alloys containing 48-50.8% Ni, quenching and annealing do not affect resistivity, whereas in the alloy with 53% Ni resistivity after quenching is 41 ohm·cm higher than after annealing. In alloys with >50.8% Ni, quenching results in the formation of the  $\beta$ -phase. Exposure at room temperature for 5500 hr does not affect the properties of quenched alloys. Prolonged annealing at 500°C for 500 hr + 450°C for 100 hr results in the formation of a fine-disperse phase and a decrease in resistivity in alloys with 50.2-51.8 at.% Ni. Alloys with 49.8-50.2 at.% Ni are unaffected by all the types of heat treatment mentioned above, because they exist in the martensitic region, whereas beginning with 50.5% Ni the high-temperature phase is stabilized by quenching. Figure 1; references 4: 2 Russian, 2 Western.

[170-1386]

USSR

UDC 669.295.017:669.785/788

INFLUENCE OF HYDROGEN ON THE STRUCTURE AND MECHANICAL PROPERTIES OF THE VT20 ALLOY

Ordzhonikidze IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: TSVETNAYA METALLURGIYA in Russian No 3, 1979 pp 111-113 manuscript received 12 Apr 78

KOLACHEV, B. A., ZHURAVLEV, L. N., SEDOV, V. I., KOTKOVA, G. V., Moscow Institute of Aviation Technology, Department of Metallography and Hot Working of Metals

[Abstract] A detailed study is presented of the influence of hydrogen on the structure and mechanical properties of the VT20 alloy, which is classified as a pseudo- $\alpha$ -titanium alloy, but does not show the typical tendency toward hydrogen embrittlement expected of these alloys at hydrogen contents of up to 0.1%. Fracture toughness testing, which is more sensitive than impact testing, shows a tendency toward hydrogen embrittlement with a hydrogen content of over 0.03%, as opposed to more typical figures of around 0.01% for other alloys of this class. VT20 should therefore be considered an  $\alpha + \beta$ -titanium alloy, with a lower tendency toward hydrogen embrittlement. Figures 2; references 6 (Russian).

USSR

UDC 620.17:669.14.018.294

CHANGE IN MECHANICAL PROPERTIES OF CAST STEEL DURING ITS PERFORMANCE

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 7, 1979 pp 39-42

KOSTENKO, N. A., TSVETKOV, V. D. and TATARINTSEV, V. A., Bryansk Institute of Transport Machine Building

[Abstract] Specimens taken from stressed regions of cast-steel freight car couplings after 7, 13, 16, and 20 years of service were subjected to tensile strength tests along with control specimens of newly cast steel "20." The test results show that after years of performance the original mechanical properties of the castings may change; in particular, the yield point increases. This points to embrittlement of the material: in this connection, the critical brittleness temperatures increase and resistance to crack development decreases. After 11-14 years of performance the yield-point plateau on the dilatational straining diagram of the couplings completely disappears and plasticity correspondingly decreases. The decrease in resistance to crack development in the transition zone of the couplings commences after

at least 11-13 years of service. The critical brittleness temperature in the transition zone of the couplings increases by more than 40-50°C after 20 years of performance. These findings must be taken into account to assure reliability in the design stage, since such changes in mechanical properties affect the determination of guaranteed and overall service life of castings as well as of their preventive maintenance. Figures 4; references 11 (Russian).

USSR

UDC 621.791.052:620.18:669.295

INFLUENCE OF THE WELDING MATERIAL AND HEAT TREATMENT ON THE MECHANICAL PROPERTIES OF SEAMS WELDED IN THE VT20L AND VT6L LITHIUM-TITANIUM ALLOYS

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 6, Jun 78 pp 20-21

ABRAMOVA, V. N., Engineer, POLYAKOV, D. A., Candidate of Technical Sciences, VAS'KIN, YU. V., Engineer, KULIKOV, F. R., Candidate of Technical Sciences, PROSTOV, I. A., Engineer and YASINSKIY, K. K., Candidate of Technical Sciences

[Abstract] A study was made to optimize the welding and heat treatment parameters in order to obtain a weld having properties equal to those of the original metal. The VT20L and VT6L lithium-titanium alloys were used in the study. Several tables list the properties of the original metals and the welds made under different operating parameters. It was determined that heating the weld to 650°C is sufficient to reduce residual stress in the welded joint. The SPT-2 welding wire and a rod of base metal (plate or cast) are recommended for welding both alloys. Seams welded in such a manner in material up to 20 mm thick are about 80% as strong as the original metal. When the filler material is the welded metal, the weld has the same strength as the original metal.

USSR

UDC 621.762:669.018.24.(088.8)

## TITANIUM-BASED SINTERED ANTIFRICTION MATERIALS

Kiev POROSHKOVAYA METALLURGIYA in Russian No 5, 1979 pp 87-91 manuscript received 26 Oct 78

YENEVICH, V. G., KARPINOS, D. M., POLOTAY, V. V., SAPOZHNIKOVA, A. B. and TUCHINSKIY, L. I., Institute of Problems of Material Science, Academy of Sciences UkrSSR

[Abstract] Titanium and titanium alloys are prone to seizing and hence they require special treatment for operation in the presence of dry friction. In this connection, the antifriction properties of sintered titanium materials impregnated with such solid lubricants as the readily fusible metals and eutectic alloys represented by tin, lead, tin-lead, tin-lead-bismuth, and tin-lead-bismuth-cadmium were investigated on specimens obtained from electrolytic Ti powder that had been pressed in a steel mold to a porosity of 25-45%, with the pressed briquets then being sintered in vacuum to a specified porosity and impregnated to the amount of 20-25 vol.% with lubricating components in an argon atmosphere by dipping into the melt. The residual porosity of the specimens after the impregnation did not exceed 2-3%. The specimens were then tested for friction and wear in an M-22P friction testing machine, in air, at two sliding rates, 0.1 and 10 m/sec, upon increasing the load in stages from 20 to 160 and from 10 to 60 kg/cm<sup>2</sup>, respectively. The friction coefficient was determined to be correct to  $\pm 5\%$ . It was found that at  $V = 0.1$  m/sec the lowest and most stable friction coefficient ( $f = 0.10-0.13$ ) and the highest wear resistance were displayed by specimens impregnated with the compositions Ti-(Bi-Pb-Sn) and Ti-(Bi-Pb-Sn-Cd), especially the latter, following an impregnation time of 60 min. Ti and Ti alloys impregnated with this composition, in particular, can be recommended for processing into products operating under conditions of dry friction (sliding bearings, bushings, packings, etc.), especially in structures for which a reduction in mass is important. Figures 6; references 4 (Russian).



## CONTACT INTERACTION OF TITANIUM AND HARD ALLOY WITH BORON NITRIDE UNDER SUPERHIGH PRESSURES

Kiev POROSHKOVAYA METALLURGIYA in Russian No 5, 1979 pp 65-68 manuscript received 20 Jul 77

MAZURENKO, A. M., ZHUK, M. M. and UL'YANOVA, T. I., Institute of Solid-State Physics and Semiconductors, Academy of Sciences BSSR

[Abstract] The contact interaction between the substrate material and cubic boron nitride under conditions of synthesis (pressures of 70-90 kbar, temperatures of 2000-2700°K) was investigated. Titanium was selected as the substrate material along with the hard alloy, since Ti is adhesion-active with respect to diamonds and cubic boron nitride is an analog of diamonds. Specimen billets were prepared by pouring a layer of substrate (VK4 hard alloy, Ti) material into the mold and topping it with a layer of powdered hexagonal boron nitride, and thereupon compacting the whole at 5-7 kbar. The obtained two-layer billets were subjected to pressures of 70-80 kbar and temperatures of 2000-2700°K for 1-2 min in a superhigh pressure chamber. Microscopic examination of the microsections revealed the presence of a 15-20 nm wide transition zone at the boundary of contact between cubic boron nitride and Ti. In the case of the hard alloy the transition zone was blurred or completely absent. X-ray micrography revealed the presence of cubic boron nitride and the nitride and borides of titanium  $Ti_2B_5$  and  $TiB$ , which points to chemical interaction between titanium and boron nitride during their synthesis. No such chemical interaction was established in specimens obtained from a mixture of hexagonal boron nitride and hard alloy. Thus the possibility of developing cutting-tool edges consisting of a layer of cubic boron nitride on a hard-alloy substrate by the catalyst-free synthesis method was demonstrated, as was the possibility of replacing the hard-alloy substrate with a metal substrate. Since the brazing of bits to tool holders entails high temperatures ( $\leq 1100-1250^\circ K$ ), the heat resistance of the bits in air at 1080 and 1270°K was investigated. At these temperatures changes in layers of cubic boron nitride and titanium were confined to the formation of a thin surface film, while in the hard-alloy layer they were more far-reaching. Figures 4; references 8 (Russian).

## CHEMICAL NICKELIZING OF IRON POWDER

Kiev POROSHKOVAYA METALLURGIYA in Russian No 5, 1979 pp 15-17 manuscript received 11 Jul 78

KURVYAKOVA, L. M., PIMENOVA, I. V. and ZAKHAROVA, YE. P., Novomoskovsk Affiliate of the Moscow Chemico-Technological Institute imeni D. I. Mendeleyev

[Abstract] The conditions in which iron powder can be nickelized so as to assure a uniform coating of particles with nickel and the maximum possible extraction of Ni from the solution are investigated. The nickelizing was performed in the presence of intensive mixing (stirrer speed 500-800 rpm) in a solution containing (in g/liter)  $\text{NiCl}_2 \cdot 6\text{H}_2\text{O}$ , 25;  $\text{NaH}_2\text{PO}_4$ , 25;  $\text{Na}_4\text{P}_2\text{O}_7$ , 50;  $\text{NH}_4\text{OH}_{\text{final}}$ , 20 cc/liter; at pH = 10 and at temperatures of 18-25°C.

Coatings were thus applied to reduced pure PZhCh-1 iron powders as well as to electrolytic iron powders obtained in the laboratory by electrolysis of aqueous solutions. The powder particle size averaged 25  $\mu\text{m}$  and the powder suspension was previously pickled in a 1% HCl solution and rinsed until there was a neutral reaction. After nickelizing, the powder was rinsed to remove electrolyte, dehydrated with acetone, and dried at 40°C. Upon addition of 100 g of iron powder per liter of solution, after 30 min 95-98% of the nickel in the solution combines with the powder. Microstructural analysis shows that at such a unit load a uniform 2-3- $\mu\text{m}$ -thick nickel coating forms on the iron particle surfaces within 15-20 min. The chemical nickelizing process also depends on the state of the powder surfaces. In reduced powder the Ni content is lower, all other conditions being equal, than in electrolytic powder. This is because the nickelizing process is markedly affected by the catalytic action of the metal surface. Apparently, electrolytic iron powder, being more pure than reduced iron powder, displays a higher catalytic activity and thus contains somewhat more nickel. Figures 2; references 5 (Russian).



## UTILIZING THE ELECTROHYDRAULIC EFFECT IN POWDER METALLURGY

Kiev POROSHKOVAYA METALLURGIYA in Russian No 5, 1979 pp 22-26 manuscript received 20 Jul 78

MALYUSHEVSKIY, P. P. and TOLSTYKH, A. B., Nikolayev, Project Design Bureau of Electrohydraulics, Academy of Sciences UkrSSR

[Abstract] The effect of hydraulic pulsed vibrators with electrical discharges (HPVED) on the compacting of metal powders was investigated in a PMM-125 compacting press equipped with HPVED. Mixtures of Fe and Ni with particle sizes of 50-150 and 1-70  $\mu\text{m}$ , as well as of commercial W with 1% Ni were experimentally subjected to this method of pulsed compaction. The operating conditions were as follows: voltage  $U = 40 \text{ kv}$ ; pulse energy  $E \sim 1.6 \text{ kJoule}$ ; operating length 40 mm; HPVED frequency 5-10 Hz, with the number of pulses being varied from 50 to 250. Compaction stress reached  $450 \text{ kg/cm}^2$ . These experiments demonstrated the fundamental feasibility of using the HPVED method to compact products from high-hardness powders. The compacted material thus obtained is of high (as much as 95%) relative density and displays a more uniform particle distribution throughout its bulk. HPVED also serves to reduce the subsequent sintering temperature, which will be the subject of a subsequent investigation. In addition, HPVED reduces the required static stress and power consumption and simplifies the technology of the compaction of powder materials. Figures 4; references 3 (Russian).

## COMPACTION OF BORON CARBIDE POWDER DURING HOT PRESSING

Kiev POROSHKOVAYA METALLURGIYA in Russian No 5, 1979 pp 38-43 manuscript received 4 Apr 78

OSTAPENKO, I. T., SLEZOV, V. V., TARASOV, R. V., KARTSEV, N. F. and PODTYKAN, V. P., Khar'kov Physico-Technical Institute, Academy of Sciences UkrSSR

[Abstract] Owing to its poor covalent bonds the stoichiometric boron carbide  $\text{B}_4\text{C}$  is poorly sintered until the highest sintering temperatures (0.8-0.9 melting point). In most cases, compact boron carbide products are obtained by the hot pressing method, yet the published literature on this subject is extremely scanty. Hence this paper deals with the kinetics of the compaction of  $\text{B}_4\text{C}$  during hot pressing at  $1800\text{-}2200^\circ\text{C}$  under a pressure of  $225 \text{ kg/cm}^2$ , on using pure boron carbide powder obtained by synthesis of elements

and consisting of  $78.2 \pm 0.5$  mass % of boron and  $21.5 \pm 0.3$  mass % of carbon plus 0.04% S and 0.20% of metal impurities. The hot pressing was conducted in a graphite mold in vacuo ( $5 \cdot 10^{-3}$  mm Hg). The specimens obtained were 60 mm in diameter and 10-20 mm high. The compaction kinetics was investigated by means of automatic recording of shrinkage with the aid of an electronic potentiometer recording the movements of the mold bottom. The final density of the specimens was determined by hydrostatic suspension in water. Microstructural analysis showed no marked grain size growth in specimens hot-pressed at 1800-1950°C. In specimens pressed at 1950-2100°C grain size increases uniformly with increase in temperature, reaching 5  $\mu$ m at 2050°C with grain composition remaining uniform. The structure of specimens obtained at 2150-2200°C is marked by nonuniformity of grain size and a large number of twins along with a small number of pores, with relative density remaining at 0.98. The compaction kinetics at hot pressing is determined by a number of mechanisms: realignment and comminution of particles, sliding along grain boundaries, viscous flow, diffusion-controlled creep, plastic deformation, etc. The compaction of boron carbide is determined by a process resulting in nonlinear creep which is characterized by the dependence of creep rate on the square of the stress applied, as determined by the investigation of the effect of applied stresses varying from 75 to 375 kg/cm<sup>2</sup> at a hot-pressing temperature of 2100°C. Figures 5; references 17: 12 Russian, 5 Western.

USSR

UDC 539.215

#### INFLUENCE OF GEOMETRIC PROPERTIES OF POWDERS ON THEIR COMPACTION

Moscow FIZIKA I KHIMIYA OBRABOTKI MATERIALOV in Russian No 3, May/Jun 79  
pp 147-151 manuscript received 28 Nov 78

SPASSKIY, M. R., SPASSKAYA, I. A., SHATALOVA, I. G. and SHCHUKIN, YE. D.,  
Moscow

[Abstract] An examination is made of the way that the shape of powder particles and granulometric composition affect the process of vibrocompacting. Measurements of microstresses in compacted structures of conglomerated and disaggregated tungsten powders, as well as the strength of such compacts, show that there is a transition zone from structural to plastic deformation. As vibration intensity increases, the density of the powder body first increases due to packing of particles in a more advantageous configuration. Beginning at some instant, phase interparticle contacts appear with a practically constant strength of about 5-6 dynes until the acting forces reach the level where they can produce plastic deformation of particles. Packing of particles can continue up to a certain critical density that is typical of the given material. The ratio of this density to the limit for

random packing gives a quantitative index of the perfection of powder geometry, which was found to be 0.86 for conglomerated powder, and 0.99 for disaggregated powder. Imperfection of the particle shape of the conglomerated powder causes a sharp increase in the vibration intensity required for packing, beginning at a packing density of 55%. This destroys the conglomerates and levels out the structural differences, beginning at a density level of 65-66%. Beyond this packing density, further compaction is accompanied by considerable plastic deformation of particles. Figures 3; references 11: 8 Russian, 3 Western.

USSR

UDC 669.14.017.001.5:620.18

## CHANGE IN THE AUSTENITE TRANSFORMATION KINETICS AND IN THE STRUCTURE OF 17G1S STEEL UNDER DEFORMATION

Sverdlovsk FIZIKA METALLOV I METALLOVEDENIYE in Russian Vol 47 No 5, May 79  
pp 998-1004 manuscript received 13 Jul 78

KHLESTOV, V. M., DOROZHKO, G. K., PODGAYSKIY, M. S., IKONNIKOV, V. I. and  
MALOVA, R. P., Zhdanov Institute of Metallurgy, Donetsk Scientific Research  
Institute of Ferrous Metallurgy

[Abstract] Regulated hot rolling is a new method of processing structural steel. Here a study was made of the austenite transformation kinetics in 17G1S pipe steel (0.17% C, 1.48% Mn, 0.61% Si, 0.02% S, 0.02% P) with attendant structural changes through the ferrite-pearlite and the bainite ranges. Specimens were cooled from the austenitization temperature to 800°C and at that temperature rolled to a 20% reduction. Specimens which had been austenitized at 950°C were cooled in isothermal steps and those which had been austenitized at 1130°C were cooled continuously at various rates after deformation. For comparison, specimens were subjected to the same treatment without deformation by hot rolling. Dilatometric and magnetometric tests as well as examination under an optical microscope and an electron microscope revealed that hot rolling decreases the stability of austenite during subsequent isothermal holding within the ferrite-pearlite range and increases it during subsequent isothermal holding within the bainite range. During subsequent continuous cooling, depending on the rate, varied here from 2 to 16°C/s, austenite transforms to ferrite-pearlite at higher temperatures and to bainite only at lower temperatures. The ferrite-pearlite structure becomes comminuted during either isothermal holding or continuous cooling, but fast cooling inhibits pearlite formation and produces instead a unique ferrite-(high carbon martensite structure in deformed steel. This feature can be utilized for additional hardening of rolled steel by fast cooling, but not too fast so as to increase its proneness to brittle fracture. Figures 5; references 8 (Russian).

USSR

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# EFFECT OF NONMETALLIC INCLUSIONS ON THE FATIGUE STRENGTH OF STEEL AFTER CASE HARDENING

Moscow STAL' in Russian No 6, Jun 79 pp 450-453

KURITS, YE. A., LYUBCHENKO, A. P., SHUR, YE. A. and ZHUKOV, N. N., All-Union Scientific Research Institute of Railroad Transportation

[Abstract] Several grades of martensitic steel (30KhGSN2A, 18Kh2N4VA, and three different ladles of 38KhS) containing nondeformable nonmetallic inclusions ( $Al_2O_3$ ,  $CaO \cdot Al_2O_3$ ,  $MgO \cdot Al_2O_3 + CaO \cdot Al_2O_3$ , TiN, but no silicates) were tested for fatigue strength after case hardening. Irregular grains of such inclusions, especially large ones (50-80  $\mu m$ ) were found to act as stress risers and to initiate fatigue cracking, thus rendering plastic deformation of the surface layer ineffective. Tempering at 400°C, after plastic deformation, was found to restore the fatigue strength by stress relaxation, if formation of microdefects within the danger zone can be avoided. Figures 4; references 8: 6 Russian, 2 Western.

USSR

UDC 669.14.018.8-419.4

# CORROSION-RESISTANT ROLLED BIMETAL STRIP

Moscow STAL' in Russian No 6, Jun 79 pp 446-450

BYKOV, A. A., Central Scientific Research Institute of Ferrous Metallurgy imeni I. P. Bardin

[Abstract] Bimetal strip consists of a thin layer of corrosion-resistant alloy steel on a base of carbon steel or of a nonferrous metal with the necessary mechanical and thermal as well as forming characteristics. It is produced by stack rolling, foundry plating, fusion, welding with subsequent rolling, or a complementary combination of processes. It is now produced at the Kommunar'skiy, Chelyabinskiy and Zhdanovskiy metallurgical plants, as well as at the Kuznetskiy and Orsko-Khalilovskiy metallurgical combines. Total production of all grades has more than doubled over the 1965-77 period and production of bimetal strip with a nickel-steel plating layer alone has more than tripled over the same period. Bimetal strip replaces strip of plain stainless steel so that scarce alloying elements such as nickel are conserved and the overall material cost is reduced, although using bimetal strip for the manufacture of equipment somewhat complicates the forming and machining operations. Bimetal strips are now produced in 4-6 and 26-60-mm thicknesses with plating layers of nickel steel (08Kh17N15M3T, 06KhN28MDT)

or Monel metal. Other nickel alloys (KhN78T and N7GMF) have been developed for plating layers. A method of producing thick bimetal strip by direct explosion plating is now being developed at the Orsko-Khalilov metallurgical combine. Figures 2; references 5: 4 Russian, 1 German.

USSR

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# STRUCTURE AND PROPERTIES OF EI-844 STEEL AFTER FAST RECRYSTALLIZATION ANNEALING

Minsk IZVESTIYA AKADEMII NAUK BELORUSSKOY SSR, SERIYA FIZIKO-TEKHNICHESKIKH NAUK in Russian No 2, Apr/Jun 79 pp 25-27 manuscript received 7 Sep 78

BODYAKO, M. N., ASTAPCHIK, S. A., BOZHOK, V. P. and SYCHEV, G. T., Physico-Technical Institute, Academy of Sciences Belorussian SSR

[Abstract] EI-844 (026Kh16N15M3BU-ID) austenitic stainless steel is used for extra-thin tubes. A critical aspect of production of this steel is control of the grain growth. A study was therefore made of recrystallization annealing with particular attention to the behavior of the carbide phase. Tube specimens with a 0.5 mm wall thickness were heated to 1000-1180°C at rates of 50 or 400°C, held there for 10-30 sec or immediately cooled in air or water. Fast heating to a high temperature and subsequent fast cooling were found to result in a sufficiently homogeneous coarse-grain structure with a low mechanical strength, while slow heating to a lower temperature and subsequent isothermal holding were found to result in a high mechanical strength but also an undesirable superfine-grain structure. Fast heating and subsequent isothermal holding, on the other hand, require a high precision to ensure stability of the mechanical properties. As a compromise, heating to 1150±20°C at the rate of 50°C/s without subsequent isothermal holding was found to yield an adequate mechanical strength above 52 kgf/mm<sup>2</sup> with grains within the 7-11 mesh sizes (diameter 15-35 μm) and a sufficiently moderate rate of carbide dissolution. Figures 2; references 2 (Russian).



## 07KhZGNM NEW LOW-CARBON HIGH-STRENGTH STEEL FOR BRANCHED WELDED CONSTRUCTION

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 6, Jun 78 pp 9-11

KLEYNER, L. M., Candidate of Technical Sciences, and POSPELOV, N. G.,  
Candidate of Technical Sciences

[Abstract] A study was made of the weldability of 07KhZGNM steel as compared with the 12Kh2NVFA steel. The new steel is lower in C, V, W, S and P and higher in Cr, Ni, Mn, Mo, and Si than 12Kh2NVFA steel. It also has superior properties (average values, 07KhZGNM listed first): limit of strength, 105 vs 101 kg/mm<sup>2</sup>; force needed to break samples, 5.24 and 2.34 kg·m/cm<sup>2</sup> at 20°C and 2.2 and 0.95 at -50°C; force needed to break weld, 5.6 vs 3.7 kg·m/cm<sup>2</sup> at 20°C and 2.4 vs 1.18 kg·m/cm<sup>2</sup> at -50°C. Similar comparisons are made for other physical and mechanical properties. The increased viscosity and plasticity of the hot-worked steel permits the martensite structure to develop. The steel is easily quenched in air for thicknesses less than 200 mm. Figures 2; references 7 (Russian).

USSR

UDC 669.295'292'71'781:539.4.015

THE EFFECT OF BORON ON THE MECHANISM OF PLASTIC DEFORMATION AND FAILURE OF ALPHA-ALLOYS OF TITANIUM

Sverdlovsk FIZIKA METALLOV I METALLOVEDENIYE in Russian Vol 47 No 4, 1979 pp 834-142 manuscript received 24 Oct 77; in revised form 24 Apr 78

LIKHACHEV, V. A., KHESIN, YU. D., BELOVA, O. S., ANDRONOV, I. N., and MEDVEDEVA, G. V., Leningrad State University imeni A. A. Zhdanov

[Abstract] An alpha-alloy of titanium with 4% Al and 2% V, to which 0.002% boron was added, was annealed in the beta-zone at 1200°C and then studied by statistical metallographic methods in terms of bands, crystal planes, and histograms. All angles were measured on a single beta-grain in order to eliminate intergranular variations. The findings are discussed in terms of external appearances and phase transformations. Crystalline changes rather than the formation of borides were regarded as the cause of changes in the metallic structure, and the presence of small boride phase deposits, along with the appearance of allotropic transformations, were seen to be the underlying causes of undesirable orientational changes affecting the impact strength of the alloys tested. Figures 5; references 7: 4 Russian, 3 Western.

USSR

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METASTABLE DIAGRAMS OF TRINARY ALLOYS OF TITANIUM WITH TWO  $\beta$ -ISOMORPHIC STABILIZERS

Ordzhonikidze IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY:TSVETNAYA METALLURGIYA in Russian No 3, 1979 pp 107-111 manuscript received 30 May 78

KOLACHEV, B. A., BELOV, S. P., Moscow Institute of Aviation Technology, Department of Metallography and Hot Working of Metals

[Abstract] A trinary system is studied, consisting of titanium and two  $\beta$ -isomorphic stabilizers. The study is used in an attempt to predict the nature of the metastable phase-state diagram of the hardened alloy on the basis of the known equilibrium state diagram. If the phase transformations which the  $\beta$  phase undergoes upon hardening are known, the metastable diagram can be predicted. Figures 5; references 7 (Russian).



## LASER WELDING AND HEAT TREATMENT

Moscow MOSKOVSKAYA PRAVDA in Russian No 44, 21 Feb 79 p 1

[Article by A. Presnyakov: "Quanta Come to the Shops"]

[Text] The thin light beam skims over the joint of two metal plates. An instant -- and a seam invisible to the naked eye joins them strongly. This is the way one of the laser welding devices developed by the Institute of Metallurgy imeni Baykov AN USSR and specialists of a number of industrial research organizations operates. An entire family of "Kvant" devices for pulse laser welding and thermal treatment was released for industrial operation.

"Many new structural materials with unique mechanical and physical properties are being born in our time," stated M. Stel'makh, doctor of technical sciences and one of the leaders in this field. "Naturally they require special processing methods. The light beam makes it possible to solve these complex problems."

Soviet scientists laid down the beginning of the thermal process theory in laser welding. As a result, laser beams acquired a number of new "trades." They weld electron-beam tubes, radio tubes and other products, exhibiting in this a truly jewel-like precision. The labor productivity of the workers in these operations has increased many times.

Having investigated mechanisms of deep melting of processed parts, the scientists of the institute proposed, for the first time, the use of the radiation of a high power oscillator for annealing also.

"The traditional methods of strengthening cutting tools by thermal treatment in special vats of salt solutions, as well as by high frequency current, were in use until today," explained M. Stel'makh. "Annealing by means of our devices improves the quality of this process considerably. A 'soft' and, at the same time, powerful light beam treats, in millionths of a second, the outer edge of the tool to a depth of only several hundred microns. In this case, it does not hurt the tool, preserving, as engineers say, the dynamic toughness of the material. Moreover, the laser treatment produces an ideal

uniform annealing of particles of the varied configurations. Their service life increases up to 10 times.

Scientists are continuing their creative searching. New models of light-energy apparatus are being created.

2291

CSO: 1842

## ACTIVITIES OF THE EXPERIMENTAL DESIGN BUREAU OF THE INSTITUTE OF ELECTRIC WELDING

Kiev RABOCHAYA GAZETA in Russian 20 May 79, p 2

[Article by G. Shklyar: "Lightning at Work"]

[Text] Twenty years ago barely more than 10 experts laid the foundation for the Experimental Design Bureau of the Institute of Electric Welding imeni Ye. O. Paton. The Bureau was established to develop new apparatus and equipment for mechanized welding techniques as well as to broadly introduce progressive welding methods into practice.

Now the staff is about 2,000, and the name is different--the OKTB [Experimental Design and Technology Bureau]. It employs doctors and candidates of engineering sciences, including winners of the Lenin and USSR State prizes.

What then are the accomplishments with which the staff celebrate the 20th year of the Bureau's existence?

The OKTB Chief, Doctor of Engineering Sciences, Honored Machine Builder of the UkrSSR, Anatoliy Ivanovich Chvertko, comments:

"Our institute is the nation's leading welding research organization. We develop, study, and introduce apparatus and equipment for virtually every known method of mechanized welding of metals, and we develop the techniques and equipment for electric welding. The ultimate result of each project is to provide the nation's economy with yet another research project by the Institute. Figuratively speaking, the Bureau is the principal link in the chain between ideas and industry. The extent of the creativity with which we work behind the partitions, in the laboratory, and in the shops of our pilot plant, affects the speed with which yet another "working lightning" appears in plants and on pipeline routes."

As is known, properly speaking, welding--that is, the use of apparatus in the process of electric welding--accounts for about 15 percent of the labor required. The remainder--time, effort, and equipment--is expended on preparation: transportation, assembling of components, trimming. Thus the time spent on ancillary operations must be reduced in order to maximize the effect.

A way out was found. The OKTB chose in favor of the mechanization and automation of basic and auxiliary operations. A variety of heavy automatic arc welding machines was developed. They are assembled by the modular method from a small number of components. Depending on how these are combined, suspension-type or self-propelled automatic welding machines for varied technological applications can be assembled.

To save time, welding must be intensified, that is the operating speeds of the automatic machines must be increased. But there is a limit to this. Thus, the traveling speed of the welding head during arc welding can be increased to 250 and more meters per hour. But then the metal begins to rebel, as it were, and welding is no longer possible.

But what if multi-position machines and facilities, including rotary lines, be used, with one worker servicing several different units at a time? The solution of this problem may be exemplified by the automatic rotary machine for arc welding of rollers at the Altay Tractor Plant.

Subsequently, the equipment and technology for simultaneous operation of several welding heads were developed. The heads travel in parallel, with each producing a separate weld. It is thus possible rapidly to weld together a metal sheet of any width.

But what if the sheet is extremely long? Then the machines operate by a method termed "tandem." The heads are positioned in a row. That is how a machine for the simultaneous welding of thin-walled gas pipe by means of six heads operates at the Kharnyz Pipe Plant.

Microplasma welding has become widely used in various branches of the national economy. It has made possible the development of thin-walled welded structures which previously could not be achieved by other techniques.

A current creative task of the OKTB staff is the development of the Sever-1 apparatus for the welding of trunk pipelines in the climate of the Far North. The resistance butt-seam welding method, which increases labor productivity and results in joints of high quality, was for the first time in the world used to weld large-diameter pipe. The welding process is completely automated, taking only two-three minutes.

Recently the OKTB has, in collaboration with branch organizations and enterprises, developed a number of complex-mechanized, semi-automatic and automatic assembly lines. A great deal of one-of-a-kind equipment has been built for new welding techniques: electron-beam and capacitor welding. Special equipment for space and underwater welding has also been built.

Consider also the K690 industrial robot, in which experts from the OKTB's divisions invested a great deal of labor. It has passed operating trials and given birth to the nation's first generation of robots for resistance and arc welding.

The equipment and technologies developed at the OKTB have made it possible to mechanize production in heavy and machine building industries as well as in railroad-car building and in the construction of atomic power stations, bridges and blast furnace complexes.

A. I. Chertko said: "Above all, we will expand the limits of applicability of mechanized welding. It is necessary to continue developing complex-mechanized and completely automated sectors, assembly and conveyer lines, and high-productivity welding machines and installations, primarily those of the multi-position kind, with several heads each. Later we will improve series-produced and all-purpose equipment. Our robot is awaiting its 'brethren.' We will work to develop robots for other welding methods.

1386

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USSR

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#### AMPLITUDE-FREQUENCY CHANGES DURING ULTRASONIC MICROWELDING

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 6, Jun 78 pp 6-7

VIGDOROVICH, V. N., Doctor of Technical Sciences, ZUYEV, I. V., Candidate of Technical Sciences, and YAFAROV, R. K., Engineer

[Abstract] Amplitude-frequency changes (AFC) during ultrasonic microwelding leads to a determination of the mechanical strength. A method was developed for measuring the AFC based on a mechanical vibrating system for the piece of work as it is being welded. The vibrating system has an asymmetrical resonance curve and the vibration envelope for the signal from the "concentrator" has a two-hump form. During welding, as the resonance frequency changes, the relationship between the resonance frequency of the system and the axis of symmetry of the frequency modulation also changes. The two-hump form collapses into a single hump. Through the use of this technique, it was established that the optimum value of the AFC, corresponding to the maximum strength of the welded seam, decreases with increasing power of the transformer. Figures 4; references 2 (Russian).

USSR

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#### WELDING OF CHEMICAL EQUIPMENT CONSTRUCTED FROM PT-3V TITANIUM ALLOY WITH ELECTROMAGNETIC AGITATION OF THE WELDING MATERIAL

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 6, Jun 78 pp 16-18

SHELENKOV, G. M., Engineer, and ONOPRIYENKO, L. M., Engineer, IEC Institute of Electric Welding imeni Ye. O. Paton

[Abstract] A study was made of the effects of electromagnetic agitation of the welding material on the mechanical properties and corrosion resistance of seams in the PT-3V pseudo- $\alpha$  titanium alloy. The PT-3V alloy contains 3.5 - 5.0% Cr as an  $\alpha$ -stabilizer, 1.5 - 2.5% Al as a  $\beta$ -stabilizer, and sufficient V to be somewhat supersaturated with respect to the  $\alpha$  phase. Properties evaluated include weld strength at different temperatures, impact viscosity of the weld metal, size of the zone of thermal alteration, and the gas content of the original material and the weld. Values are given for these parameters for a wide variety of conditions. The results confirm the assumption that this treatment would improve the mechanical and corrosion-resistance properties. The mechanism, also analogous to that worked out for the VT1-0 Ti alloy, is the reduction in grain size, decreased linear size of the crystals, increased homogeneity of the  $\alpha$ -phase and also an increased passivity of the structurally homogeneous welds. Figures 1; references 4 (Russian).



THE INFLUENCE OF PROCESSES MODIFYING THE WELDING MATERIAL ON THE MECHANICAL AND CORROSION-RESISTANCE PROPERTIES OF SEAMS IN THE OT4-1 TITANIUM ALLOY

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 6, Jun 78 pp 4-6

BOLDYREV, A. M., Candidate of Technical Sciences, PETROV, A. S., Engineer, DOROFEYEV, E. B., Candidate of Technical Sciences (Volgograd Polytechnical Institute), and STEKLOV, O. I., Doctor of Technical Sciences (Moscow Higher Technical School imeni N. E. Bauman)

[Abstract] A study was made of the effects of adding powdered titanium, powdered zirconium, or a mixture of the two (0.3% Zr) to the welding material. The mechanical properties were determined on standard samples of the seam having a small diameter. The corrosion-resistance properties were evaluated from the amount of force required to break the seam after it had been treated with a 20% solution of mineral acid for 24, 84 and 168 hours at 20°C. The extent of corrosion of the metal weld formed with a welding material containing the Ti-Zr powder and subjected to a magnetic field decreased with increasing corrosion time. Decreasing the grain-size in the metal of the weld through the use of the special weld material and the magnetic field not only increases the plasticity of the metal but also, by decreasing its chemical microheterogeneity, decreases the rate at which the weld metal corrodes. The Zr seems to be a better additive for the weld metal than Ti. Figures 2; references 4 (Russian).

FEATURES OF TRANSFORMATIONS IN THE HEAT-AFFECTED ZONE DURING THE WELDING OF SOME HIGH-STRENGTH ALUMINUM ALLOYS

Kiev AVTOMATICHESKAYA SVARKA in Russian No 5, May 79 pp 26-29 manuscript received 26 Sep 77

ISHCHENKO, A. YA., Candidate of Technical Sciences, and SKLABINSKAYA, I. YE., Engineer, Institute of Electric Welding imeni Ye. O. Paton, Academy of Sciences UkrSSR

[Abstract] The properties of weld joints made from new thermally hardenable 1201, 1915, 1915 and 01420 aluminum alloys were studied to determine what transformations take place in the heat-affected zone during welding. During welding of these artificially aged aluminum alloys, intense transformations occur in the base metal in the active zone at temperatures above 300°C. The change in hardness in hardened or naturally aged alloys can be observed

in the active zone above 150°C. Artificial aging of weld joints leads to increased hardness in all sections of the heat-affected zone. If only the hardened metal is welded, a higher hardness is produced after aging joints where the metal had been partially annealed and overaged. The nature of hardness change in the heat-affected zone after welding and artificial aging depends on the features of structural transformations. In weld joints of 01420 alloy there was an absence of dips on the hardness change curves at those points where other thermally strengthened alloys are significantly weakened due to overaging and partial annealing. Evidently, under conditions of the welding cycle for thin sheet of 01420 alloy, the growth of particles of the strengthening metastable phase and the formation of stable phase precipitations do not develop due to the low rate of solid solution decomposition. One can assume that in this alloy only recovery to the hardened state occurs to a varying degree in the entire section of thermal actions which creates conditions for recovery of hardness throughout the entire heat-affected zone during repeated artificial aging of the base metal. This feature of transformations in 01420 alloy is probably a specific single-stage mechanism of strengthening phase precipitation. The weakening and width of the heat-affected zone is diminished in the transition from 01381 and 1201 alloys to 1915 and 01420. When 01420 alloy is welded it is possible to obtain a weld joint strength of over 40 kgf/mm<sup>2</sup>. Figures 2; references 5 (Russian).

FLAMELESS METALLURGY -- A NEW METHOD FOR DIRECT PRODUCTION OF IRON

Moscow PRAVDA in Russian 6 Jun 79 p 2

[Article by A. Presnyakov (Moscow)]

[Text] The Institute of Metallurgy imeni A. A. Baykov of the AN USSR has a laboratory for producing iron which directly bypasses the blast furnace process. It would seem that no one in the world would be surprised by this since, in many countries, including the Soviet Union, such methods are used practically on an industrial scale. Yet, what we saw was a pleasant surprise.

M. Gromov, senior scientific staff worker began the conversation.

"Under the usual natural conditions," he said, "iron is bound by the strongest 'fetters' of oxygen and is, moreover, surrounded by rock. Metallurgists first enrich the ores, clean out the iron oxides, then reduce the iron, removing the oxygen. Blast furnaces quench the need for the most important metal of these times. At the same time, another technological idea is gathering strength: obtain iron directly from the ore without giant fire-breathing furnaces. Our laboratory is developing research which was begun by academician A. Samarin and scientific staff worker, K. Bogdanovich in their time."

However, the scientist stated that even the intensive development of the new direction in metallurgy would not be an obstacle to the progress of blast furnace production. Both technologies could coexist completely. The traditional method will satisfy mass production needs as before. The problem of the new technology will be to supply precision instrument building and machine building with the purest metal.

Fundamental research and large-scale experiments on direct production of iron has intensified considerably in the leading scientific centers in the world. Original designs of new machines are being drawn and built. No melting is done in the machines, but the charge is heated to a temperature at which gas or other fuel removes oxygen from the iron.

Interest was recently exhibited in implementing this process in mine furnaces. They have a high unit productivity, use less heat and are convenient to service. In the very near future, it is planned to build mine furnaces for this purpose in the United States, England and Canada. Such machines will be built in the Soviet Union at the Oskol'skiy Metallurgical Combine.

We enter the room where the mysteries of obtaining the purest iron from ore are being performed. Glass jars glisten on the table. In one of them is magnetite containing 72 percent iron, 27 percent oxygen and less than one percent rock. Having removed the oxygen from it, it is possible to obtain a practically pure metal. But first it is necessary to achieve a very high degree of raw material enrichment.

Senior engineer A. Smolyakov pours ground ore with a large amount of rock into the bin of the installation and throws the power switch. I can see through the window how the black cyclone begins to turn in the machine. Falling into the rotating magnetic field, the dust particles begin to act like rotors of crushing electric motors -- the speed of their rotation is 3000 rpm. The centrifugal forces that originate tear off particles of the rock adhering to the magnetite, since the rock does not interact with the magnetic field, and fall freely as tailings.

"The electromagnetic method for obtaining superconcentrated magnetite," explains the engineer, "is very efficient. Electromagnetic separators with a productivity of 50 tons of concentrate per hour are being designed at present."

Various types of ore serve as raw materials for metallurgy -- magnetites, hematites and limonites. All of them are mixtures of oxidized iron and rock. But while magnetites have magnetic properties and are easily purified of rock in the separator, hematites and limonites must first be roasted in rotary furnaces after which they acquire magnetic properties.

However, there is another way. Scientists in the laboratory are developing universal action vortex chambers. In these machines it is possible not only to roast the ore, giving it magnetic properties, but also to reduce pure iron from iron oxides.

Before us is a cylindrical chamber crowned by a conical bin. Finely crushed ore is poured into it and gas is fed to the chamber. One can see through the transparent wall that the ore ground to a powder is caught by the stream of gas and completes a head-spinning carousel from the upper to the lower sector. The gas is fed to each sector separately. Bent into a special helix, the stream turns from left to right in one sector and conversely in the other. There is another special feature -- the powder drops down gradually while the gas, twisted into a vortex, is directed upward. Counterblasting each particle with hot air accelerates the process for which the chamber is set: either roasting or reducing pure iron from ore.

"In an industrial installation," remarked one of the developers of the process, B. Khaylov, "the roasting of raw material will be done by gas heated to 900 degrees and about 1000 degrees -- when producing pure iron. Compact, efficient vortex chambers will be able to replace cumbersome rotary roasting furnaces and machines for direct reduction of iron. The Tula metallurgists plan to test the vortex chambers there. A semiproduction installation is being designed now."

"The prospects of the new metallurgical process are very attractive," continued L. Petrov, manager of the laboratory. "It does not require blast furnace coke, achieves an impressive saving of fuel and electric power and does not pollute the environment. And if the research people use hydrogen as the reducing agent, as they plan to do in the future, the production waste will be ... ordinary water."

The institute's scientists made calculations of processes for producing metal by means of hydrogen, electrically charged and heated to 10,000-12,000 degrees. Such a plasma is capable not only of melting, but also of converting the metal to the vapor phase. Iron condensed from the vapors will have a record purity.

Thus, we watched the pre-dawn of a new phase of the iron age being started by the research of the scientists of today.

2291  
CSO: 1842

## RECRYSTALLIZATION OF TWO-PHASE NIOBIUM ALLOYS TREATED WITH ZIRCONIUM AND NITROGEN

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 7, 1979 pp 23-27

SHEFTEL', YE. N., USMANOVA, G. SH., and GRIGOROVICH, V. K., Institute of Metallurgy imeni A. A. Baykov

[Abstract] Dispersion-hardened Nb alloys are promising new materials. The alloys with the disperse nitride phase display a particularly high heat resistance at operating temperatures of  $\sim 1200^{\circ}\text{C}$ . In this connection, since knowledge of the pattern of structure-formation in these alloys is needed for the selection of optimal regimes of heat treatment and deformation, the effect of annealing on the structure and hardness of cold-rolled Nb alloys treated with 1-3.0 wt.% Zr and 0.2-3.2 wt.% N and having the at.% Zr/at.% N ratio of from 0.9 to 20 was investigated. The alloy ingots were annealed at  $1450^{\circ}\text{C}$  for 3 hr and processed into billets by forging and rolling. After annealing at  $1400^{\circ}\text{C}$  for 1 hr these billets were cold-rolled into 1-mm-thick sheets which were then annealed at  $500-1200^{\circ}\text{C}$  in quartz ampoules at  $5 \cdot 10^{-5}$  mm Hg, and also at  $1300-2000^{\circ}\text{C}$  in a TVV-4 type high-temperature furnace at a residual pressure of  $2 \cdot 10^{-5}$  mm Hg. The properties of these alloys were found to be largely determined by their at.% Zr/at.% N ratio. When the stoichiometric ratio at.% Zr/at.% N = 1, the principal structural component determining the alloy properties is the disperse nitride phase. Such alloys display the maximum strength. The disperse nitride phase inhibits grain growth in the process of accumulative recrystallization. The alloy with 3% Zr and the ratio at.% Zr/at.% N = 1 is maximally resistant to grain growth. It is this that accounts for the marked increase in the heat resistance of Nb alloys at high temperatures. Figures 6; references 8 (Russian). [170-1386]



## FAILURE STRENGTH OF CERTAIN STRUCTURAL MATERIALS AT LOW TEMPERATURES

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 7, 1979 pp 49-51

KOGUT, N. S., L'vov Polytechnic Institute

[Abstract] The failure strength of high-strength heat-resistant steels and titanium and aluminum alloys widely used in various branches of industry was investigated as a function of their chemical composition, melting method, alloying, and tempering temperatures. Cylindrical specimens with artificially induced annular cracks were subjected to static tensile tests and dynamic impact tests at temperatures ranging from +20°C to -196°C on a test stand equipped with a cryostatic chamber. The findings were used to assess the failure strength of the investigated materials. Of the heat-resistant steels tested the greatest cold resistance was displayed by 10Kh11N20T3R steel. In the VT3-1 titanium alloy and 13Kh12M2VMF, 14Kh17N2 and 28KhNMVFA steels increasing the test temperature enhances proneness to brittle fracture while in aluminum alloys this does not affect cold brittleness. Of the aluminum alloys the maximum cold resistance is displayed by the AL23-1 Al-Mg base alloy. The impact tests corroborated the results of static tests, except that then the cold brittleness threshold of the steels and alloys shifted somewhat in the direction of plus temperatures owing to the increase in straining rate. Figures 2; references 2 (Russian). [170-1386]

## INFLUENCE OF HIGH-TEMPERATURE PLASTIC DEFORMATION ON THE KINETICS OF AUSTENITE TRANSFORMATIONS

Moscow FIZIKA I KHIMIYA OBRABOTKI MATERIALOV in Russian No 3, May/Jun 79 pp 120-124 manuscript received 21 Mar 78

KHLESTOV, V. M., GOTSULYAK, A. A., ENTIN, R. I. and KOGAN, L. I., Moscow

[Abstract] Studies were done on the influence that deformation has on the kinetics of austenite transformations in Kh2G2R steel with carbon content of 0.07-0.42%. A "magnetic balance" facility was used for studying ferrite-perlite and bainite transformations. It was found that high-temperature plastic deformation accelerates ferrite-perlite transformation of austenite, and that the effect increases with the temperature of transformation and the

degree of deformation. The acceleration is particularly pronounced in steel with the lowest carbon content. The accelerating effect is attributed to an increase in the density of dislocations and vacancies in the crystal structure. The reduction in the effect as carbon content increases is due to the reduction in the concentration of free vacancies as they interact with the carbon atoms. High-temperature plastic deformation retards bainite transformation of austenite, and the effect is more pronounced at lower transformation temperatures and higher carbon contents. The retarding effect decreases with deformations beyond 30%. Bainite transformation is accelerated at transformation temperatures above about 400°C. The causes for the effect of plastic deformation on bainite transformation are changes in the fine structure of austenite and the rate of carbon diffusion. Figures 5; references 8 (Russian).

USSR

UDC 539.374:669.35'295

#### SOME PARTICULARS OF THE STRUCTURE AND PROPERTIES OF Cu-Ti ALLOY AGED WITH ULTRASONIC DEFORMATION

Moscow FIZIKA I KHIMIYA OBRABOTKI MATERIALOV in Russian No 3, May/Jun 79  
pp 116-119 manuscript received 17 Jun 77

BAZELYUK, G. YA., BEREZINA, A. L., POLOTSKIY, I. G. and CHUISTOV, K. V.,  
Kiev

[Abstract] Studies were done on the effect of ultrasound on dissociation of a solid solution of an alloy of copper with 3.5% titanium in the temperature region where segregation follows the sequence: "modulated" structure  $\rightarrow$  intermediate  $\alpha'$ -phase ( $\text{Cu}_3\text{Ti}$ ) with tetragonal lattice ( $c/a = 0.98$ )  $\rightarrow$  equilibrium stable  $\beta$ -phase of  $\text{Cu}_3\text{Ti}$  with orthorhombic lattice. The alloy was melted in argon in a high-frequency induction furnace. Ultrasonic treatment was done with the UZG-10M ultrasonic oscillator and a PMS-15A magnetostriction transducer with a resonant frequency of 18 kHz. It was found that ultrasonic deformation accelerates the process of dissociation. This accelerating action is apparently due to an increase in concentration of point defects. The increase in hardness of the alloy after aging is greater when aging is done in an ultrasonic field. This effect is due to the formation of dislocation pile-ups and also the presence of particles of intermediate  $\alpha'$ -phase. Figures 3; references 5: 3 Russian, 2 Western.

USSR

UDC 621.791.85

CALCULATION AND EXPERIMENTAL DETERMINATION OF THE DISTRIBUTION OF CURRENT DENSITY OVER THE CROSS SECTION OF AN ELECTRON BEAM

Moscow FIZIKA I KHIMIYA OBRABOTKI MATERIALOV in Russian No 3, May/Jun 79  
pp 35-38 manuscript received 2 Jun 77

ZVYAGIN, V. B., ZUYEV, I. V., PODOL'SKIY, V. P. and UGLOV, A. A., Moscow

[Abstract] When a wide electron beam is used for machining, it is important to know how the current density is distributed over the beam cross section. It is shown that the Pierce method may distort the shape of this distribution. A technique is proposed for selecting initial data to eliminate the distortion. A method is proposed for additional processing of experimental data if they do not meet the proposed conditions. An example is given of use of the method in calculating distribution of current density in the electron beam of the industrial A.306.13 facility. The results are compared with direct processing of experimental data by the Pierce method. Figures 3; references 8: 5 Russian, 3 Western.

USSR

UDC 539.4.019.1:539.3

INTERACTION OF DETONATION WAVES AND HIGH-VELOCITY PULSED GAS FLOWS WITH DISPERSED MATERIALS IN POWDER-BLAST SURFACING

Moscow FIZIKA I KHIMIYA OBRABOTKI MATERIALOV in Russian No 3, May/Jun 79  
pp 24-29 manuscript received 2 Aug 77

KHARLAMOV, YU. A., Voroshilovgrad

[Abstract] An examination is made of features of the interaction of detonation waves and streams of detonation products with powder particles in explosive surfacing facilities. Four cases are considered: 1. a gas suspension of powder in a hot mixture occupies a given limited region of the barrel at a given distance from the open end; 2. a compact batch of powder is located on the wall of the barrel or on a special shelf at a given distance from the open end; 3. a gas suspension of powder in a hot mixture is uniformly distributed through the volume of the barrel; 4. the gas suspension of powder is located in the atmosphere in front of the open end of the barrel. Equations are derived for the flow of the two-phase mixture of gas and powder under conditions of gas detonation. The results show that consideration of the initial placement of the powder is important for intensifying exchange of thermal and kinetic energy between the products of

gas detonation and dispersed particles when developing technological processes and equipment for detonation surfacing with powder. Figures 1; references 8 (Russian).

USSR

UDC 539.26:620.18

# STACKING DEFECTS AND PLASTIC DEFORMATION IN ZINC IRRADIATED WITH MILLSECOND LASER PULSES

Moscow FIZIKA I KHIMIYA OBRABOTKI MATERIALOV in Russian No 3, May/Jun 79  
pp 15-19 manuscript received 5 Mar 77

MIRKIN, L. I. and SMYSLOVA, YE. P., Moscow, Ryazan'

[Abstract] Studies were done on zinc foil 100  $\mu\text{m}$  thick which were pre-annealed at 200°C for an hour. The specimens were exposed to infrared laser beams ( $\lambda = 1.06 \mu\text{m}$ ) in pulses of  $10^{-3}$  sec with an energy of 30 and 300 J. ✓ Pulse energy was calorimetrically measured with an error of 20%. Flux density in both cases was  $1.7 \cdot 10^5 \text{ W/cm}^2$ . The substructural changes resulting from laser exposure were studied by x-ray (radiography) techniques at small and large scattering angles. It was found that the plastic deformation of the foil caused by the laser beam is accompanied by development of deformational stacking defects. The stacking defect concentration is less than 1%. Nonuniformity of energy distribution through the cross section of the laser beam causes higher concentration of stacking defects in the center of the laser spot. The authors thank YE. F. SMYSLOV for assistance in the work. Figures 4; references 13: 12 Russian, 1 Western.

USSR

UDC 669.296:536.42:539.89

$\alpha \rightarrow \omega$  TRANSFORMATION IN ZIRCONIUM DURING DEFORMATION UNDER HIGH PRESSURE

Sverdlovsk FIZIKA METALLOV I METALLOVEDENIYE in Russian Vol 47 No 5, May 79  
pp 1109-1111 manuscript received 28 Jun 78

BLANK, V. D., VELLER, M. YE., KONYAYEV, YU. S. and ESTRIN, E. I., Institute  
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[Abstract] Evidence has been found of some hysteresis in the pressure dependence of the  $\alpha \rightarrow \omega$  transformation in zirconium, within the range between phase equilibrium (below 60 kbar at room temperature) and the beginning of spontaneous transformation (60 kbar). Here a study was made to establish the feasibility of producing the  $\omega$ -Zr phase by plastic deformation of the  $\alpha$ -Zr phase under pressures lower than 60 kbar. Cylindrical specimens of ionindated  $\alpha$ -Zr were subjected to hydroextrusion with counterpressure, then chemically polished for microhardness measurements and phase analysis. The results indicate that  $\omega$ -Zr can be produced by plastic deformation alone under pressures down to 28-30 kbar, but not under lower pressures, with the microhardness of  $\omega$ -Zr increasing linearly from 240 kgf/mm<sup>2</sup> at zero deformation to 400 kgf/mm<sup>2</sup> at 76% deformation (microhardness of undeformed  $\alpha$ -Zr is 120 kgf/mm<sup>2</sup>). Figures 4; references 9: 4 Russian, 5 Western.

USSR

UDC 669.71'5:539.375

CHANGING INSTANTANEOUS DEFORMATION RATES IN HYPERPLASTIC SPECIMENS UNDER TENSION

Sverdlovsk FIZIKA METALLOV I METALLOVEDENIYE in Russian Vol 47 No 5, May 79  
pp 1075-1080 manuscript received 21 Mar 78; after revision 14 Jul 78

PRESNYAKOV, A. A., AUBAKIROVA, R. K., GORBACHEVA, L. K. and DEGTYAREVA, A. S., Institute of Organic Catalysis and Electrochemistry, Academy of Sciences Kazakh SSR

[Abstract] Local deformation during hyperplastic flow in metals and alloys under tension is analyzed on the basis of experimental data pertaining to the eutectoid aluminum-zinc alloy. With cylindrical specimens 5 or 7 mm in diameter and 20 mm in gauge length mounted in a tensile testing machine, both apparent (mean) and true instantaneous stresses and deformation rates were measured during the final necking stage at several temperatures from 100°C (below hyperplasticity) to 275°C (maximum hyperplasticity). A relation

between stresses and deformation rates is established which indicates that the deformation rates within the neck region increase continuously to levels much higher than the mean deformation rate and, furthermore, oscillate in a "traveling neck" pattern. The distribution of true local stresses is found to be very nonuniform within the hyperplastic region and these stresses also fluctuate but not as widely as the local deformation rates. The true stresses remain almost independent of the true deformation rates over a wide range of the latter, this range becoming wider at higher temperatures, and during the final stage of deformation the deformation rates can increase while the material softens. Figures 6; references 6: 3 Russian, 1 German, 2 Western.

USSR

UDC 669.15'24'28:669.112.227.346.2

EFFECT OF THE INITIAL STATE OF AUSTENITE ON THE KINETICS OF 2-STAGE MARTENSITE TRANSFORMATION IN IRON-NICKEL-MANGANESE AND IRON-NICKEL-MOLYBDENUM ALLOYS

Sverdlovsk FIZIKA METALLOV I METALLOVEDENIYE in Russian Vol 47 No 5, May 79 pp 1038-1043 manuscript received 18 Jul 78; after revision 5 Oct 78

GEORGIYEVA, I. YA., MATYUSHENKO, L. A., Institute of Metal Science and Physics of Metals, Central Scientific Research Institute of Ferrous Metallurgy imeni I. P. Bardin

[Abstract] A study was made to determine the effect of heat treatment of austenitic iron-nickel-manganese and iron-nickel-molybdenum alloys on the kinetics of their  $\delta$ - $\alpha$  martensite transformation. The experiment employed alloys of the  $\text{Fe}_{70+x}\text{Ni}_{30-x}\text{Mn}_x$  ( $0.6 \leq x \leq 4$ ) series and three variants of the N24M5 alloy: vacuum-furnace 24% Ni+ 5.45% Mo and open-furnace 24.6 (24.3)%Ni+ 5.1(4.9)%Mo. Cast ingots of these alloys were forged into rods, which were then drawn into wires 4 and 1 mm in diameter. The specimens were held at 1100°C for 30 min or at 1150°C for 60 min and quenched in water, then annealed at 200-650°C and held either in a lead bath for 2-30 min or under vacuum for 120 hrs. The 2-stage transformation, first isothermal and then athermal, was tracked by thermal expansion and electrical resistance measurements during continuous cooling at rates from 5 to 10°C/min. The two martensite transformation temperatures  $M_{s1}$  and  $M_{s2}$  served as indicators of the transformation kinetics, changing with heat treatment of the original austenite and, in the case of iron-nickel-manganese alloys, also with the composition parameter  $x$ . The trend of the transformation kinetics is attributed to structural and magnetic nonhomogeneity of the austenite in these ternary alloys. The authors thank Academician V. D. SADOVSKIY for discussing the work and for suggestions on setting up some of the experiments. Figures 6; references 12: 11 Russian, 1 Western.



USSR

UDC 669.35:620.181

**MORPHOLOGY, STRUCTURE AND FEATURES OF PRECIPITATES IN INTERNALLY OXIDIZED ALLOYS OF COPPER WITH TITANIUM, CHROMIUM AND IRON**

Sverdlovsk FIZIKA METALLOV I METALLOVEDENIYE in Russian Vol 47 No 5, May 79 pp 1024-1032 manuscript received 22 Apr 77; after revision 7 Aug 78

DANELIYA, YE. P. and TEPLITSKIY, M. D., State Scientific Research and Planning Institute of Alloys and of Nonferrous Metals Processing, Moscow

[Abstract] Copper-titanium alloys alone and with the addition of chromium or iron are used as heat-resistant conductor materials whose hardness and electrical conductivity can be increased by internal oxidation. For the purpose of explaining the mechanism of this process and the effect of chromium and iron admixtures to a binary copper-titanium alloy, a morphological and structural study was made of precipitated oxides in three such alloys (Cu+ 1.1% Ti, Cu+ 0.69% Ti+ 0.9% Fe, Cu+ 0.65% Ti+ 0.98% Cr). Rolled plates 0.1, 0.25 and 0.5 mm thick were internally oxidized at 850 or 950°C, with a Cu<sub>2</sub>O film deposited on the specimen surface serving as the oxidizer. The phase composition, the size distribution of oxide particles, and the interplanar distances were measured electronographically. Here the results are interpreted in terms of oxidation reaction parameters, two possible microstructures produced by oxidation of a 2-phase alloy, and the concentration distributions of alloying elements and of oxygen. According to this analysis, the rate of buildup of the internal-oxidation zone in the ternary copper alloys follows the same general trend as in the binary copper alloy and is controlled by oxygen diffusion through this zone. Figures 6; references 17: 8 Russian, 4 German, 5 Western.

USSR

UDC 661.665.2

**SECONDARY ION EMISSION FROM BORIDES AND CARBIDES OF TRANSITION METALS**

Sverdlovsk FIZIKA METALLOV I METALLOVEDENIYE in Russian Vol 47 No 5, May 79 pp 1010-1015 manuscript received 3 Aug 78

VASIL'YEV, M. A., Institute of Metal Physics, Academy of Sciences UkrSSR

[Abstract] Stoichiometric boride and carbide phases are the basis of many general-purpose and special-purpose alloys of transition metals. Mass-spectrometry of secondary ion emission from these materials is an effective method of chemical analysis and has, in this study, been used for determining the characteristics of such solid solutions. The experiment was performed in vacuum, with specimens of vacuum-sintered borides and hot-molded carbides

serving as targets. The surfaces of the latter were all bombarded with identical beams of 8 keV argon ions with a current density of  $10^{-3}$  A/cm<sup>2</sup> striking at a 30° angle, to minimize the effects of surface impurities and selective sputtering. Measured were both the ion work function and the ion emission normal to the surface. An evaluation of the data on the basis of a theoretical relation for the energy dispersion of secondary ions indicates that the sputtering coefficients of said compounds are of the same order of magnitude as those of their components. The ion work function and the ionization coefficient are lowest for pure metals and become successively higher for carbides and borides, as the atomic bond changes from a metallic to an ionic-covalent one. Figures 3; references 14: 10 Russian, 4 Western.

USSR

UDC 669.15.24.292:537.311.31

#### CHANGE IN THE ELECTRICAL RESISTIVITY OF IRON-NICKEL-VANADIUM ALLOYS DUE TO HEATING

Sverdlovsk FIZIKA METALLOV I METALLOVEDENIYE in Russian Vol 47 No 5, May 79 pp 967-971 manuscript received 6 Jun 78

ZAYTSEVA, R. D., PERKAS, M. D., Institute of Metal Physics; Central Scientific Research Institute of Ferrous Metallurgy imeni I. P. Bardin

[Abstract] The electrical resistivity of martensite-aging Fe-Ni-V and Fe-Ni-Co-V alloys does not reach its minimum at the temperature of maximum hardness but at somewhat higher temperatures. A special experiment was performed to establish the cause of this anomaly. The relative decrease of electrical resistivity of five alloys (10%Ni+ 7% V, 10%Ni+ 10% V, 18%Ni+ 7% V, 18%Ni+ 10% V, 18%Ni+ 15% Co+ 10%V) was measured at -196°C and at 20°C with or without precooling at -196°C, after specimens of these alloys had been quenched from 1000°C and subsequently heated to and held for 1 hr at various temperatures over the 200-800°C range. In addition to the Vickers hardness and the relative change of electrical resistivity, the percentage of residual austenite at the test temperature was determined as a function of the isothermal heating temperature. The results indicate that austenite, already stabilized at 20°C, has a lower electrical resistivity than martensite. The electrical resistivity of one-phase (martensite) alloys therefore remains almost constant over the range of low temperatures, while that of two-phase (martensite+ austenite) alloys decreases rapidly with decreasing temperature and the trend of the temperature characteristic of the electrical resistivity from 20 to -196°C indicates at what temperature austenite in these alloys begins to stabilize. Figures 3; references 7: 6 Russian, 1 Western.

USSR

UDC 669.15'25'26:539.89:538.22

ON THE EFFECT OF PLASTIC DEFORMATION ON THE MAGNETIC PROPERTIES AND STRUCTURE OF IRON-CHROMIUM-COBALT ALLOYS

Sverdlovsk FIZIKA METALLOV I METALLOVEDENIYE in Russian Vol 47 No 5, May 79 pp 943-948 manuscript received 14 Jul 78

SHUR, YA. S., BELOZEROV, YE. V., MAYKOV, V. G., SERIKOV, V. V., YURCHIKOV, YE. YE., KLEYNERMAN, N. M., LAPINA, T. P., SHCHEGOLEVA, N. N. and MAGAT, L. M., Institute of Metal Physics, Ural Science Center, Academy of Sciences USSR

[Abstract] Iron-chromium-cobalt alloys are used for permanent magnets because of their excellent magnetic properties and formability. A study was made to determine the effect of plastic deformation by cold rolling, after various modes of heat treatment in a magnetic field or without one, on the magnetic properties and the structure of the polycrystalline 47% Fe+ 23% Cr+ 29% Co alloy with 0.5% Si and 0.5% Mo. The material was produced in an argon atmosphere in an induction furnace. Cast specimens were deformed at 1100-1200°C to a 3.0-mm thickness. Plate and wire specimens were obtained by cold rolling, pressing, or drawing. Their structure was examined by x-radiography, electron microscopy, nuclear-gamma resonance and nuclear-magnetic resonance. A 30% deformation after the first stage of heat treatment at 640°C for 40 min was found to increase both the residual magnetic induction and the maximum energy product, especially as a result of rolling in the direction of the magnetic field applied during heat treatment. Deformation was found not to change the  $\alpha_2$ -phase content in specimens but to lower its degree of ordering. Figures 3; references 9: 5 Russian, 4 Western.

USSR

UDC 548.3

STUDY OF THE SOLUBILITY OF IRON IN ALUMINUM AND IN SAP TYPE MATERIALS BY THE METHOD OF NUCLEAR MAGNETIC RESONANCE

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY--CHERNAYA METALLURGIYA in Russian No 5, May 79 pp 92-97

NECHAYEV, YU. S., YEDIGAROV, V. S. and PUSTOV, YU. A., Moscow Institute of Steel and Alloys

[Abstract] Methods of gamma-resonant spectroscopy, chemical analysis and residual resistivity measurement were employed to study the equilibrium solubility of iron ( $\text{FeAl}_3$ ) in aluminum crystals having an ordinary dislocation density ( $10^6 \text{ cm}^{-2}$ ) and in crystals of the SAP type. The changes in enthalpy and entropy were determined upon dissolving a mole of  $\text{FeAl}_3$  in the

aluminum lattice. It was found that at high temperatures there is a significant increase in the average concentration of dissolved iron atoms in aluminum with a density of  $10^9 \text{ cm}^{-2}$  as well as a significant fraction of iron in a state which yields a doublet in the spectrum. Analysis of the results allows one to propose the presence, near the dislocations, of regions with high local concentrations of iron atoms which produce a doublet and a singlet in the moessbauer spectrum. References 14: 6 Russian, 8 Western.

USSR

UDC 621.777.07

#### PROCEDURE FOR CALCULATING THE STRENGTH OF CYLINDRICAL WHISKERS WITH THE AID OF A COMPUTER

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY--GHERNAYA METALLURGIYA in Russian No 5, May 79 pp 89-91 manuscript received 20 Feb 78

STAROSTIN, YU. S., KARGIN, V. R. and ORLOV, YU. O., Kuybyshev Aviation Institute

[Abstract] Using the theories of elasticity, expanding the boundary conditions of a Fourier series and applying the principles of superposition were incorporated to produce a series of equations which were then solved on an ES-1020 computer. The results of these calculations showed how the different stresses acted in a metal whisker. It was established that when radial stresses act on the whisker surface the body of the whisker is in a plane stress state, and the magnitude of the tensile stress is approximately zero. The stress components vary along the whisker length in conjunction with the boundary conditions and were constant across sections perpendicular to the whisker axis. When tangential stresses act on the whisker surface the whisker body is in a uniaxial stress state. The axial stresses depend on the form of tangential load, the ratio of length to diameter and the number of expansion members in the Fourier series. The longer the whisker the greater its axial stresses. In order to produce the accuracy needed for technical applications it is necessary to limit the number of Fourier series members to 10. When normal and tangential stresses act simultaneously on the whisker surface, the surface is in a volume stress state. The surface layers of the whisker encounter the heaviest conditions since the tangential stresses diminish from the periphery to the center. The most dangerous section is located near the whisker tail. Figures 2; references 6 (Russian).

## ADHESION-MECHANICAL WEAR OF STAMPS

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY--CHERNAYA METALLURGIYA in Russian No 5, May 79 pp 84-88 manuscript received 20 Nov 78

KHAYRETDINOV, E. F., Ufa Aviation Institute

[Abstract] An overall analysis was made of the adhesion-mechanical form of wear for stamps made of EI958, DI22 and 3Kh2V8 steels and ZhS6K and ZhS6U alloys which were used to form various parts made of Ni- and Ti-base alloys. An attempt was also made to find means to increase the durability of these stamps. Stamps made from the steels had to be taken from the production line for reasons of erosion cracks (3-6%), adhesion-mechanical wear (80-88%) and plastic deformation (8-12%), while for those made from the alloys 70-80% were removed for adhesion-mechanical wear and 20-30% for plastic deformation. Analysis of several lubricants showed that Enamel EVT-24 + graphite (in comparison with glass lubricant No. 209 and Enamel EVT-24) had the lowest coefficient of friction. Using stamps made from ZhSI alloy (ZhSI is alloy ZhS6U + hafnium) in stamping VT9 alloy turbine blades made it possible to reduce the specific wear of stamps operating at 950°C and a pressure of 20 kgf/mm<sup>2</sup> to 0.068 g/(hr-cm<sup>2</sup>), as compared with ZhS6U alloy--1.03 g/(hr-cm<sup>2</sup>), with the resultant wear being 0.05 mm for 500 stampings using ZhSI as compared to 0.2 mm using ZhS6U. When using the specified lubricant it is possible to produce 1,000 stampings using ZhSI as compared to only 250 stampings for ZhS6U. Figures 3; references 6 (Russian).

## EXPERIMENTAL DETERMINATION OF THE CONTACT SURFACE OF REAGENTS IN POWDER MIXTURES

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY--CHERNAYA METALLURGIYA in Russian No 5, May 79 pp 12-15 manuscript received 3 Mar 78

ARKHIPOV, V. S. and SMOL'YANINOV, S. I., Tomsk Polytechnical Institute

[Abstract] The technique of stereology was used to determine the magnitude of reagent contact surface in mixtures of iron oxide and graphite with varying degrees of grinding. Graphite content was 20% of the total weight in all compositions. Contact surface was determined by random sectioning of the powders and examination under a biological microscope. The investigated structure showed a continuous phase of red iron oxide in which particles and

aggregates of black graphite particles were localized. The graphite phase amounted to 10-15% of the mixture volume. After examining the powders which had been polymerized using styrene at 80°C for five hours, the powders were subjected to kinetic tests where a mixture of 50 mg iron oxide and 12.5 mg graphite was reduced in a helium-filled quartz ampule under isothermal conditions at 1050°C. The duration of the reduction process was closely associated with the contact surface of the iron oxide by a nonlinear relationship. This method can be used as a structure parameter which qualitatively characterizes the effectiveness of grinding and mixing of components in charges for reduction. Figures 1; references 9: 7 Russian, 2 Western.

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